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Rocky Flats Environmental Technology Site

FINAL

Fate and Transport Modeling of Volatile Organic Compounds at Rocky Flats Environmental Technology Site

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Executive Summary

This report summarizes computer modeling results of the fate and transport of volatile organic compounds (VOCs) present in groundwater at the Rocky Flats Environmental Technology Site (RFETS or Site) in Golden, Colorado. Results can be used for developing decisions about contaminated groundwater and for the Comprehensive Risk Assessment (CRA) that is part of the Remedial Investigation/Feasibility Study for the Site. The model estimates maximum, or long-term, groundwater VOC concentrations that may discharge to surface water at the Site.

Modeling Scope

The modeling scope included the following steps:

- collected, synthesized, and reviewed all historical VOC data;
- developed a flow and transport model of historical conditions to determine appropriate parameter values; and
- developed a flow and transport model to predict long-term (or probable maximum) groundwater VOC concentrations for a proposed closure configuration that could discharge to surface water.

The modeling scope included simulation of saturated zone transport only within unconsolidated material and weathered bedrock that define the Upper Hydrostratigraphic Unit (UHSU) at RFETS. VOCs in the UHSU do not migrate downward through the much lower permeability unweathered bedrock of the Lower Hydrostratigraphic Unit (LHSU) and into the underlying regional Laramie-Fox Hills Aquifer (RMRS, 1996).

Simulation of VOC fate and transport within the unsaturated zone or surface streams was not considered. Surface water impacts from groundwater VOCs were not modeled or assessed. The scope also did not include the simulation of the fate of any contaminants other than VOCs. Rather than simulating the fate and transport of total VOCs in groundwater, individual VOCs were modeled because differences in their chemical properties cause them to transport at different rates. Finally, this study did not evaluate the performance of current groundwater collection systems.

VOCs associated with the PU&D Yard Plume, south of the Present Landfill, were not considered in this modeling. They are addressed in a separate report.

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Modeling Approach

The approach used to develop flow and transport models involved several steps. First, historical VOC groundwater concentration data were collected and analyzed. Then Historical Release Report (HRR) information was evaluated and incorporated into a database/Geographical Information System (GIS) so this information could be further assessed in conjunction with available hydrologic and hydrogeologic information to identify possible groundwater VOC sources. Using the GIS, observed groundwater VOC concentration data were spatially associated with historical release information to identify likely sources. In general, VOCs detected in the greatest number of groundwater sample locations exhibited the highest concentrations. A total of 19 VOC-impacted areas, referred to as plume signature areas (PSAs), were identified where at least one source explained a group of associated groundwater concentration sample locations. PSAs represented an attempt to identify approximate, but distinct, source-plume areas. As such, PSA delineations were uncertain due to uncertainties in VOC source information and the complexity of historical groundwater flow pathways.

Further data analysis suggested that most PSAs probably have already intercepted groundwater discharge areas. Moreover, relatively steady VOC concentrations in time observed at most sample locations suggested that PSAs have probably reached stable configurations, though some areas may still be developing (i.e., 903 Pad area). The steady well concentration trends also suggested that VOC sources have probably reached steady concentrations in time. Non-aqueous phase liquid (NAPLs) VOC sources typically produce long-term, steady, dissolved phase concentrations in groundwater.

Primary VOCs considered in this study were tetrachloroethene (PCE), carbon tetrachloride (CCl_4), and their daughter products. Successive daughter products of PCE include trichloroethene (TCE), cis-1,2-dichloroethene (cis-1,2-DCE), and then vinyl chloride (VC). Successive daughter products of CCl_4 include chloroform (CCl_3) and then methylene chloride (CCl_2). The occurrence of both parent and daughter product VOCs within most PSAs suggested that biodegradation occurs at RFETS, though an independent study suggested rates are variable but low throughout the model area. Additional evidence suggested that TCE occurred as a source in several areas, though it is probably also a degradation product of PCE.

Draft CRA surface water preliminary remediation goals (PRGs), which define the relative risks associated with each VOC, were used as the basis for determining whether individual PSAs would be modeled. The total number of PSAs modeled was reduced to nine for PCE, 10 for TCE, and seven for CCl_4.

Modeling Results - Current Conditions

The current distribution of VOCs for each PSA was evaluated using a groundwater flow path analysis and a sensitivity analysis of reactive transport for the PCE and CCl_4 degradation chains. Iterative groundwater flow path analysis was conducted for eight different model areas (at least one PSA in each model). The results confirmed initial assumptions about possible VOC source locations, the number of sources, timing of sources, and groundwater pathways and travel velocities. Results showed that it was reasonable to assume groundwater sources were introduced approximately 30 to 50 years ago. HRR information supported this conclusion. Flow path analysis resulted in 22 different source areas that explained concentration distributions in the 19 separate areas.

Several conclusions were made from the reactive transport sensitivity analysis conducted for each PSA. Many factors affected the fate and transport of VOCs from source release time to present. The most important included:
(1) hydraulic conductivity; (2) depth of source introduction; and
(3) biodegradation rates. Factors such as sorption, dispersion, source concentration, diffusion, and porosity affected the fate and transport less significantly. The range of effective source concentrations and source depths, determined through this modeling, reproduced the range of historical time-averaged concentrations within each PSA for both parent and daughter VOCs.

Modeling showed that three-dimensional groundwater flows were important in supporting a detailed flow and transport model for the Site. Groundwater flows downward in upper mesa areas, but then flows upward near the bottom of hillslopes or streams due to the hillslope structure. This is important in the conceptual model because slower flow rates from sources allow for more efficient degradation (mostly within bedrock) before it eventually emerges at stream areas. Because evapotranspiration (ET) dominates near-stream hydrology at RFETS, model results indicated increasing amounts of VOCs in groundwater were lost via ET near streams. This loss to ET was significant because it helped attenuate VOCs in groundwater within most PSAs before discharging as baseflow to streams, seeps, ponds, or overland flow.

Model Results – Proposed Closure Configuration

Proposed land configuration modifications were simulated in the local-scale integrated flow model for the Industrial Area (IA). The integrated modeling produced a three-dimensional flow field for reactive transport modeling of the closure configuration and was used to identify areas where groundwater discharged to the land surface. Discharge frequency and rates were also calculated by the model, but the model did not simulate groundwater discharge to streams along North Walnut, Woman Creek, or South Walnut in the B-pond area. The Site-Wide Water Balance (SWWB) model was used to predict actual discharge locations, rates, and frequency in these areas, but the original SWWB

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closure scenario configuration was modified to reflect the current proposed land configuration.

Simulated closure-condition groundwater flow velocities changed little from the current configuration. This was because hillslope morphology (surface and bedrock topography) strongly controls groundwater flow directions at RFETS. The largest flow direction changes occurred near buildings with deep foundations where footing drains were assumed to be deactivated (Buildings 371, 771, 881, and 991); along South Walnut Creek east of Building 991; and where the proposed channel was re-engineered to eliminate roadways, fenced areas, and associated culverts. Local flow directions near the current Mound Groundwater Collection System changed notably due to this proposed reconfiguration.

Simulated closure-condition groundwater levels increased throughout the model area due to the proposed land reconfiguration. In some seep areas, groundwater discharged to three of four modified IA streams (drainage between Buildings 371 and 771, the drainage along South Walnut south of Building 991, and in the drainage west of Building 371). Average conditions indicated that the discharge occurred only in the drainage between Buildings 371 and 771.

Sensitive transport model parameters were adjusted to produce a range of simulated concentrations that bracketed the distribution of available time-averaged VOC concentrations within each PSA. This same range of parameter values was then used to simulate multiple closure configuration reactive transport model simulations and to estimate a range of possible groundwater concentrations at groundwater discharge areas. Simulations were run long enough to produce steady concentrations at groundwater discharge areas.

In four of the eight PSAs modeled, at least one of the closure-condition simulations produced long-term groundwater concentrations for TCE or CCl_4 that were above the draft surface water PRGs at groundwater discharge areas. These PSAs include:

- the East Trenches area;
- the Oil Burn Pit/Mound area;
- Building 771; and
- Ryan's Pit/903 Pad area.

Of these areas, only Building 771 had average groundwater concentrations (for all closure-condition simulations) below draft PRGs at groundwater discharge areas.

Closure-condition integrated flow modeling results indicated that groundwater discharged to several areas. Groundwater discharged to the surface drainage west of Building 771 due to shallow bedrock and the Arapahoe Formation "No. 1

Sandstone" (herein referred to as Arapahoe Sandstone) in the area. Although the Arapahoe Sandstone is only present as shallow, discontinuous lenses throughout the model area and has no connection to the much deeper regional confined aquifer (i.e., Laramie/Fox Hills Aquifer), it is more permeable than the surrounding claystone/siltstone matrix and controls local groundwater flows. For a typical climate, some simulated groundwater discharged into the South Walnut Creek drainage north and down-gradient of the Mound Groundwater Collection System. The discharge area increased during precipitation events. Southeast and down-gradient of the Ryan's Pit area, groundwater discharge was also simulated to the SID and Woman Creek, but only during larger precipitation events. The integrated flow model did not simulate groundwater discharge to south Walnut Creek, though this probably occurs, for example to Pond B-2.

In general, simulated results indicated that only parent compounds CCl_4 and TCE were above draft PRGs at groundwater discharge areas. All other daughter products and PCE did not. For the other PSAs not listed above, simulated groundwater VOC concentrations in groundwater discharge areas for closure simulations were below the draft PRGs. This is due to a combination of the following:

- slower groundwater velocities in bedrock (caused by typically unsaturated unconsolidated material in upper hillslope areas);
- the simultaneous combined effect of attenuation processes (such as biodegradation, sorption, volatilization, and ET loss) reduced VOC concentrations in groundwater discharge to surface areas; and
- loss through volatilization (not simulated with the reactive transport model but results in conservatively high concentrations).

In most PSAs, the dominant attenuation process appeared to be low rates of biodegradation, though ET loss is more significant in the eastern PSAs (i.e., southeast of the 903 Pad area and in the East Trenches area). Although, parameter values for each closure configuration model reproduced historical time-averaged concentrations, some combinations underestimated concentrations while others over-predicted concentrations. The latter case likely over-predicted long-term closure concentrations at groundwater discharge areas. As such, a single run should not be considered to be an accurate representation of closure concentrations, or even the most reasonable. Rather, the range of predicted output should be used in assessments.

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Acronyms and Definitions

°C	Degrees Celsius
°F	Degrees Fahrenheit
af	Artificial Fill
msl	average mean sea level
Arapahoe Sandstone	Refers to the Arapahoe Formation No. 1 Sandstone, described in more detail in EG&G (1995a, and 1995b) as sandstones that occur only within the UHSU weathered bedrock material. This sandstone is discontinuous and lenticular.
BZ	Buffer Zone
CCl_2 or CH_2Cl_2	Methylene chloride (also dichloromethane, or methylene dichloride)
CCl_3 or $CHCl_3$	Chloroform (also trichloromethane)
CCl_4	Carbon tetrachloride (also tetrachloromethane)
CDPHE	Colorado Department of Public Health and Environment
cf	Cubic feet
cis-	Refers to the "cis" isomeric configuration of an organic compound.
CRA	RFETS Site Comprehensive Risk Assessment
DCA	Dichloroethanes in general, including: 1,1-DCA and 1,2-DCA. 1,1-DCA is the more common isomer in RFETS groundwater and is the first daughter of the natural dechlorination of 1,1,1-TCA.
DCE	Dichloroethenes in general, including: cis-1,2-dichloroethene (CHCl=CHCl); trans-1,2-dichloroethene; and 1,1-dichloroethene (CH_2=CCl_2). All three DCE isomers are potential first daughters of the dechlorination of TCE. Cis-1,2-DCE is the most abundant daughter produced by biodegradation of TCE, and cis-1,2-DCE is the second daughter of the PCE decay chain. A further complication is that 1,1-DCE is also a potential first daughter of 1,1,1-TCA.
discretization	The representation of a model domain into a group of discrete cells, or elements.

DNAPL	Dense Non-aqueous Phase Liquid. Refers to halogenated hydrocarbon solvents that are denser than water. DNAPLs like carbon tetrachloride, have a limited solubility in groundwater, and are sometimes found as a separate liquid phase in an aquifer, or monitoring well.
DO	Dissolved oxygen concentrations measured in groundwater samples at the time of sampling.
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
ER	Environmental Restoration
ET	Evapotranspiration
f_{oc}	The fraction of organic carbon by weight in a soil.
ft	Foot or Feet
FY	Fiscal Year
GIS	Geographic Information Systems
GW	Groundwater
IA	Industrial Area
IHSS	Individual Hazardous Substance Site, numbered for identification.
in	Inch(es)
Kaiser-Hill	Kaiser-Hill Company, LLC.
K_b	"Bulk attenuation rate constant" determined for a specific time interval from a plot of natural log of analyte concentration versus distance along a contaminant flowpath. Positive rates indicate that natural attenuation is occurring along the flowpath. The units of K_b in this report are "per year".
K_d	The "partition coefficient" or "distribution coefficient" in ml/g, is the equilibrium ratio of the mass of a chemical sorbed on a solid phase, to its concentration in aqueous solution. Commonly used as a simple approach to modeling chemical adsorption by soils.
K_h	Horizontal Hydraulic Conductivity
KH	Kaiser-Hill Company, LLC.
km	Kilometer(s)

K_{oc}	The distribution coefficient in ml/g, describing the adsorption of an organic chemical from aqueous solution to a substrate of organic carbon in soil. Used with f_{oc} to estimate K_d values for CAHs.
K_s	Soil Hydraulic Conductivity
K_{sat}	Saturated Hydraulic Conductivity
K_v	Vertical Hydraulic Conductivity
LHSU	Lower Hydrostratigraphic Unit
LNAPL	Light Non-aqueous Phase Liquid. LNAPLs are less dense than water and often float on top of the groundwater table. Gasoline and jet fuel are examples of LNAPLs.
m	Meter(s)
m/s	Meter(s) per second
m/yr	Meter(s) per year
m^2	Meter(s) squared
m^3	Cubic meters
m^3/s	Meter(s) cubed per second
MCL	Maximum Contaminant Level
mg/L	Milligram per liter
MIKE 11	Surface water modeling computer software
MIKE SHE	Integrated ground and surface model computer software
mm	Millimeter(s)
MODFLOW	U.S.G.S. Groundwater Modeling computer software
MSL	Mean Sea Level
N/A	Not Applicable
NAPL	Non-aqueous Phase Liquids. They may be mixtures of chlorinated solvents, or mixtures of solvents and hydrocarbons of unknown density.
PCA	Perchloroethane, e.g. 1,1,1,2-PCA, a potential parent of 1,1,2-TCA.
PCE	Tetrachloroethene, or perchloroethylene, $CCl_2=CCl_2$, was an important solvent used in industrial operations at RFETS, and is the parent molecule of its decay chain. One solvent brand used at RFETS was called "Perclene".
PET	Potential Evapotranspiration
PRG	Preliminary Remediation Goal

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PSA	"Plume signature area", a local area of RFETS under which the groundwater contains detectable concentrations of one or more chlorinated solvents. This term is defined by Prucha et al. (2003). Each of the more than two dozen PSAs identified at RFETS has been assigned an integer identification number.
Q	Flow rate
Qal	Valley Fill Alluvium
QC	Colluvium
QC	Quality Control
Qp	Piney Creek Deposits
Qrf	Rocky Flats Alluvium
RFCA	Rocky Flats Cleanup Agreement
RFETS	Rocky Flats Environmental Technology Site
SID	South Interceptor Ditch
Site	Rocky Flats Environmental Technology Site
SW	Surface water
SWD	Soil and Water Database
SWWB	Site-Wide Water Balance
S_y	Unconfined Storage Coefficient
SZ	Saturated Zone
TCA	Trichloroethanes: 1,1,1-trichloroethane (CH_3-CCl_3), and 1,1,2-trichloroethane ($CHCl_2$-CH_2Cl). 1,1,1-TCA is the more common TCA isomer in groundwater at RFETS, and is the parent of a decay series. It decays mainly to 1,1-dichloroethane, or to acetic acid (acetate ion), but a fraction may decay to 1,1-dichloroethene.
TCE	Trichloroethene, $CHCl{=}CCl_2$, is a manmade industrial solvent that was used at RFETS. It can also occur from the dechlorination of PCE. TCE concentrations in groundwater can be the result of its release to the environment or from degradation of PCE.
trans-	Refers to the "trans-" isomeric configuration, usually of halogen atoms on opposite sides of a carbon double bond.
ug/L	Microgram per liter
UHSU	Upper Hydrostratigraphic Unit
USGS	United States Geological Survey

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UZ	Unsaturated Zone
VC	Vinyl chloride, or chloroethene, $CH_2{=}CHCl$, is produced naturally by dechlorination of any of the DCE isomers. VC can be thought of as the third daughter of PCE decay, or the second daughter of TCE decay.
VOC	Volatile Organic Compound
WY	Water Year

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1.0 INTRODUCTION

This report summarizes the development, application, and results of subsurface flow and transport models used to simulate the fate and transport behavior of dissolved volatile organic compounds (VOCs) at the Rocky Flats Environmental Technology Site (RFETS or the Site).

The flow and transport model was developed as a management tool to support decisions made about VOC-impacted groundwater at the Site, and the Comprehensive Risk Assessment (CRA) that is part of the RFETS Remedial Investigation/Feasibility Study (RI/FS). Within the CRA scope, human and ecological risks are determined from VOCs in groundwater reaching the ground surface discharge areas (herein assumed to include seeps, streams, or ponds). As a result, it was necessary to determine the most probable ranges of maximum VOC concentrations where groundwater discharges to seeps or surface water. Accurate estimation of concentrations using a model was not possible due to uncertainties associated with groundwater VOC sources, such as locations, depths, concentrations, and timing.

The complex three-dimensional groundwater flow and transport processes at RFETS precluded using simple analytical methods to predict maximum concentrations. As a result, a fully-distributed numerical flow and transport model was developed to predict possible ranges of maximum concentrations given source uncertainties.

The main objectives of the flow and transport modeling conducted for the CRA are summarized in Section 1.1. The modeling scope associated with the integrated flow and transport modeling is presented in Section 1.2. The report outline is described in Section 1.3, and limitations are described in Section 1.4.

1.1 Modeling Objectives

Three modeling objectives were identified. These are described below in order of importance:

- estimate a range of possible long-term concentrations for VOCs of concern in groundwater at surface discharge areas (i.e., seeps, streams, or ponds) for a proposed Industrial Area (IA) closure configuration;

- estimate areas where groundwater, impacted by VOCs, may discharge to the surface; and

- develop an integrated hydrologic flow model of the IA that may be used to assess groundwater and surface water response of proposed closure configuration modifications and integrated hydrologic response to potential groundwater collection system designs.

Although current groundwater collection systems were included in the flow and transport models to reproduce observed conditions, they were omitted from long-term closure simulations. The numerical resolution of models developed in this study was too coarse to adequately capture the local flow and transport dynamics associated with these systems. As such, the models developed were not intended to be used to evaluate the performance of these systems. Higher concentrations were estimated at groundwater discharge locations when the systems were left out of the model.

1.2 Modeling Scope

The modeling scope described here was developed to meet the project objectives outlined above. The following discussion outlines what is, and what is not included in this modeling scope.

This study considered the VOC transport in groundwater from assumed source areas to estimated groundwater discharge areas associated with streams, seeps, and ponds. VOC transport in surface water, or in the unsaturated zone, was not considered in this study because VOC concentrations in groundwater at discharge areas are conservatively high compared to the VOC concentrations in surface water in those areas. Once VOCs in groundwater discharge to surface water, concentrations likely decrease rapidly due to volatilization and degradation by sunlight.

The fate and transport of VOCs were simulated long enough to estimate steady-state groundwater concentrations at potential groundwater discharge areas. These long-term simulated concentrations represent maximum concentrations assuming source concentrations remain constant over time. This is reasonable for chlorinated VOCs, typically introduced into the environment as Dense Non-Aqueous Phase Liquids (DNAPLs), that are denser than water and flow downwards to lower permeability layers. Typically, DNAPL sources represent long-term sources of dissolved VOCs in groundwater that support specifying constant source concentrations in long-term simulations. In some instances, it will take many years for the dissolved contaminants to reach these discharge locations, especially with closure modifications to the Site.

This modeling scope considered both hydrologic effects and subsequent VOC fate and transport in groundwater due to proposed closure configuration modifications. Information on the proposed closure configuration is current as of July 2003. It should be noted that other alternative closure configurations were not analyzed in this study. The flow and transport models developed here can be modified to evaluate effects of other alternatives.

Only VOCs and their degradation products detected within the IA were considered in the current study. For example, even though VOCs have been detected in the Present Landfill area, they were not modeled in this study. Transport modeling only considers VOCs and not radionuclides, metals, nitrates, or other dissolved or free phase (non-aqueous phase) contaminants. Moreover, only the fate of a select number of VOCs, detected at the greatest spatial frequency in wells across the Site and which are above current CRA-proposed surface water preliminary remediation goals (PRGs), were simulated. Generally, concentrations for these selected VOCs also exhibited the highest concentrations compared to other VOCs.

Total combined VOC concentrations in groundwater at discharge areas were not simulated. Each VOC moves in groundwater at different rates due to differences in chemical properties. As such, each VOC was modeled individually to simulate their fate and transport.

Although an integrated flow model of the IA was developed to meet the modeling objectives, only saturated zone flow and transport of VOCs was considered. The CRA modeling only required that the groundwater concentrations at discharge areas be estimated. As such, only a saturated zone flow model was required to simulate the advective-dispersive transport. Very little information exists on VOC sources, their form and distribution, and/or occurrence within the unsaturated or saturated zones. Without detailed information on VOC source configurations in the saturated zone, possible source concentrations must be determined through modeling. As a result, there was no need to consider flow and transport within the unsaturated zone or surface flow systems.

The integrated hydrologic flow model was developed with an appropriate spatial discretization to simulate VOC transport and hydrologic effects of RFETS closure. If the model is to be used as a design tool in the future, (e.g., for groundwater collection systems), grid refinement will be necessary to improve localized prediction accuracy. Furthermore, the hydrologic impacts of closure configurations using the Integrated VOC Flow Model can only be evaluated within the model area, a smaller area than covered by the Site-Wide Water Balance (SWWB) model. The smaller size permits higher grid resolution. It does not include features such as ponds, or the extents of Woman and Walnut Creek from the IA to Indiana Street to the east for reasonable computational efficiencies.

It is typical in flow and transport modeling that the quality and quantity of data are limited given the complexity inherent within most systems. As such, the model was used to predict a range of concentrations at groundwater discharge areas, rather than a single value that is subject to input uncertainty. This range reflected the uncertainty in all of the factors controlling transport of VOCs at RFETS.

1.3 Key Modeling Factors and their Uncertainties

This section describes key modeling factors and their associated uncertainty. This was essential for developing reliable predictions to meet objectives stated in Section 1.1. To estimate VOC concentrations in groundwater at discharge areas for the assumed closure configuration, suitable saturated zone flow and transport computer codes had to be used. Developing reliable models depended on the accuracy of all model inputs. As such, the range of uncertainty in model inputs was assessed so that uncertainty in model predictions (i.e., discharge area concentrations) could be determined.

The conceptualization of flow and VOC transport in RFETS groundwater is complex and dependent on many factors. Although, much of the current VOC concentration distributions in groundwater can be attributed to advective transport (groundwater flow), other important transport processes contribute to the currently observed three-dimensional concentration distributions. Each factor that controls either the flow, or VOC fate, and transport has uncertainties due to quality (i.e., sampling errors) and/or quantity (insufficient data) limitations. In addition, information on the system stresses, response (i.e. climate variability), land configuration changes with time, or water level variability also have uncertainty caused by measurement error and have quantity limitations (i.e., data gaps).

These factors influenced the overall quality of the conceptual flow and transport model, which was based on the most accurate understanding of the system. Important processes considered in developing the conceptual flow and transport model included the following:

- Groundwater Flow:
  - infiltration-recharge from surface system to the groundwater;
  - evapotranspiration (ET) from vegetation;
  - groundwater flow - pathways and velocities;
  - groundwater discharge to the surface in the form of baseflow to streams or seeps;
  - hydraulic influence of subsurface features at IA resulting from Site operations; and
  - groundwater collection systems currently in operation.
- Fate and transport processes:
  - degradation of dissolved VOCs due to biological activity;
  - dispersion controlled by the flow and subsurface heterogeneity;
  - sorption and desorption from the porous medium;
  - molecular diffusion;
  - volatilization; and
  - ET.

Estimating reliable ranges of groundwater VOC concentrations in discharge areas depended on two important factors: (1) VOC source information; and (2) observed groundwater VOC concentration data. Information on VOC sources was important for simulating long-term fate and transport, but it was limited both in quantity and quality at RFETS. This is true of most sites. As a result, several assumptions are made about VOC sources to model their fate and transport. Some of these include the following:

- concentration of dissolved constituents in the groundwater at the possible locations;
- depth at which the dissolved mass flux enters the groundwater;
- volume over which the source is active;
- date(s) of source release; and
- type of source (i.e., single or multiple VOCs, slug, or continuous source).

Plume characterization was another important element affecting fate and transport modeling. Time-averaged concentrations in RFETS wells were, in many cases, due to multiple sources (i.e., commingling of plumes) or due to variations in source concentrations over time. The relationship between sources and concentrations in each well was uncertain. As such, our approach was iterative and required assumptions associating observed well concentrations with assumed source areas. Every attempt was made to justify the source locations, but these assumptions lead to uncertainty.

Uncertainty associated with these assumptions strongly influenced the accuracy and reliability of model predicted concentrations. In fact, the uncertainty was large enough at RFETS, that it precluded the development of a more traditional "calibrated" flow and transport model to simulate highly accurate fate and transport of VOCs in groundwater. Instead, a sensitivity analysis was used (as described in Section 1.4) to produce a range of possible groundwater VOC concentrations under the proposed closure configuration that bound the range of model parameter uncertainty.

1.4 Modeling Approach and Report Organization

The key steps taken in the development of the integrated flow and VOC fate and transport model for the IA are summarized on Figure 1.1. The first step, described in Section 2.0, was to obtain, synthesize, and interpret available hydrologic, geologic, and chemical (constituent concentration) data. This step was critical in defining where gaps exist with respect to data quantity and quality.

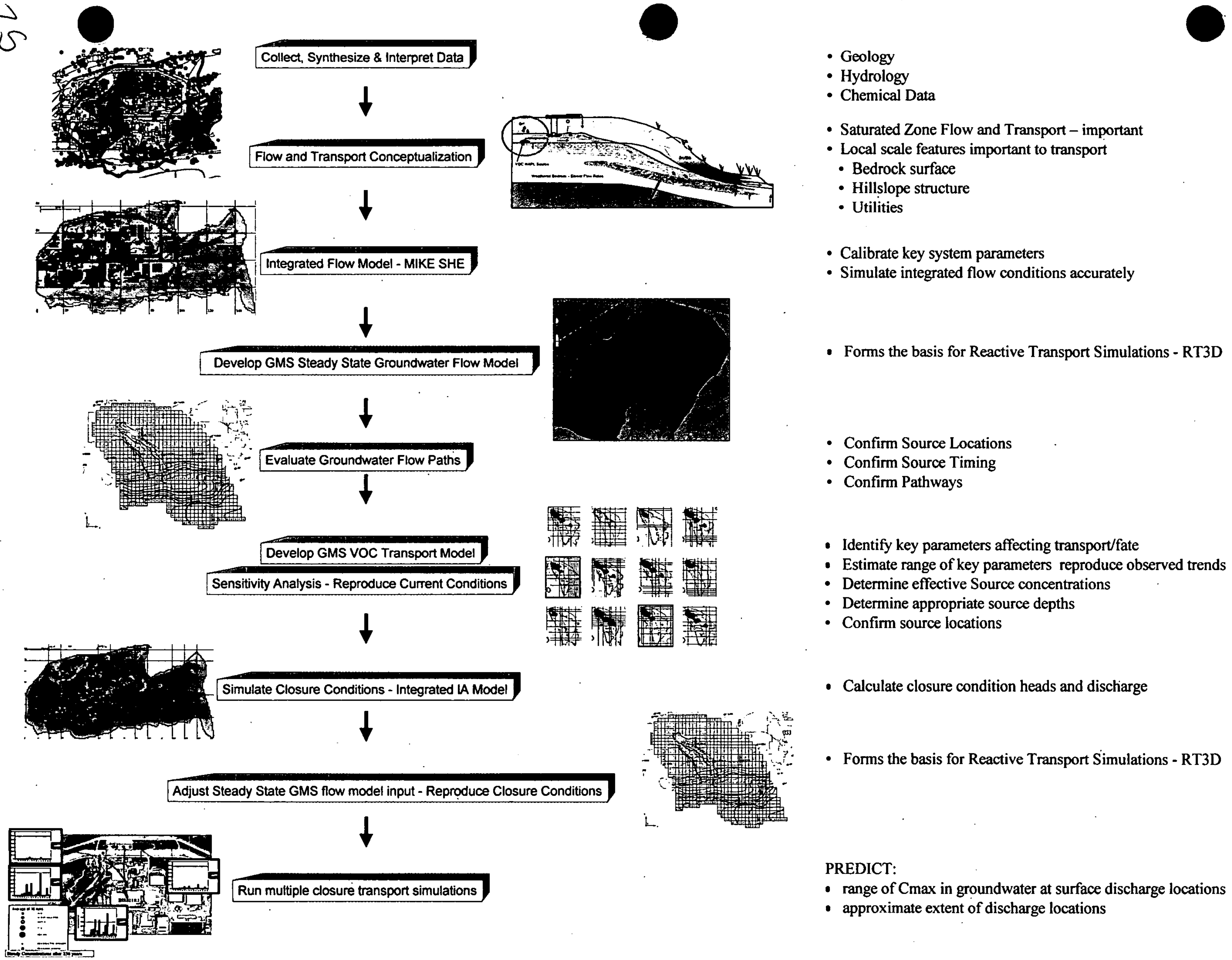

Figure 1.1. Modeling approach

In the second step, a detailed and consistent conceptual flow and transport model was developed for the IA and eastern area (Section 3.0). The IA conceptual flow model is similar to the SWWB model, but it describes the fate and transport of VOCs in the IA groundwater. The MIKE SHE code was used to develop a more refined integrated hydrologic flow model of the IA than that developed for the SWWB. A refined flow model was needed to simulate transport more accurately. The development of this model was similar to that described in the SWWB Modeling Report (Kaiser-Hill, 2002).

An integrated hydrologic flow model of the IA and the adjacent eastern area, more refined than the regional SWWB model, was developed to better resolve local-scale flow conditions. Model development and results for simulation of current conditions Water Year 2000 (WY2000) are described in more detail in Section 4.0.

Steps taken in the flow and transport code selection process are summarized in Section 5.0. These steps involved defining model needs, selection criteria, and the selection process. The Groundwater Modeling System (GMS) developed by the United States Department of Defense (DOD) and supported by the Department of Energy (DOE) was selected.

The development and modeling results of individual steady-state GMS MODFLOW groundwater flow models are described I`n Section 6.0 for individual plume areas where VOC concentrations were above currently proposed CRA goals. The parameter estimation code, PEST, available in the GMS software, was used to help automate the flow parameterization. The number, locations, and source release times of VOCs into groundwater in individual plume areas were evaluated using the particle tracking software, MODPATH, developed by the USGS. Given the complex system and flow parameter uncertainties, sensitivity of key flow model parameters was bracketed over a reasonable range in which observed groundwater level distributions and discharges could be reasonably reproduced.

The development and modeling results of reactive transport models to simulate the fate and transport of VOCs in groundwater are also described in Section 6.0. In this section, effective source area concentrations, source depths, source locations and key transport parameters were identified. In addition, ranges of values for key model input parameters (that adequately reproduce observed concentration distributions) were estimated for each plume area. The RT3D code, developed by the Pacific Northwest National Laboratory (http://bioprocess.pnl.gov/rt3d.htm), was used to model the reactive transport of observed VOC degradation chains, along with other attenuation processes including sorption, diffusion, dispersion, and ET. RT3D is an extension of the more popular MT3DMS multi-species transport computer software.

To simulate groundwater conditions for the proposed closure configuration, various model input parameters were modified based on details provided by Site personnel. Details of this modeling are presented in Section 6. Results of these simulations were used to identify discharge areas for typical and wet-year climate, which in turn were used to assess the potential of discharge of VOCs into surface waters.

Proposed closure configuration simulation results from the integrated flow model were also used as the basis for simulations using the GMS MODFLOW and RT3D codes. Long-term VOC fate and transport simulations for various closure configuration runs are described in more detail in Section 6.0. A range of long-term, maximum groundwater VOC concentrations at discharge areas are estimated in this section. The ranges of concentrations simply reflect uncertainty in key flow and transport model input parameter values. Results of multiple runs are then compared against currently proposed surface water PRG values. This information, in combination with groundwater discharge areas calculated using the integrated flow model, provides a basis for the CRA analysis of VOCs discharging from groundwater to surface water.

Summary and conclusions are presented in Section 7.0, and references are listed in Section 8.0.

2.0 DATA COMPILATION AND ANALYSIS

The collection and compilation of geologic, hydrologic, and chemical data to support delineation of current VOC sources and associated plumes are described in this section. Large amounts of data required database development and careful, iterative spatial analyses using various GIS techniques. The original data required filtering and analysis for the purposes of this study.

2.1 Geologic Data

Well geologic data locations (as of August 2002) are presented on Figure 2.1. The symbols indicate the lowest formation penetrated by the well. Some areas, such as the IA and Solar Ponds areas, contain many geologic data points whereas others to the east and southeast of the 903 Pad area have less data and more uncertainty about subsurface geology.

2.1.1 Weathered and Unweathered Bedrock Depths

The three geologic units at the Site from the surface down are the unconsolidated deposits (alluvium and colluvium), weathered bedrock (mostly claystone with Arapahoe Sandstone lenses), and unweathered bedrock. In this study, the term Arapahoe Sandstone refers to the Arapahoe Formation "No. 1 Sandstone" that is discontinuous and occurs only within the UHSU (see Section 3.2 for more discussion). Maps of the depth to weathered bedrock (contact with the overlying unconsolidated deposits) and the depth to unweathered bedrock are shown on Figure 2.2 and Figure 2.3. The interpolated bedrock surfaces were prepared for the SWWB model (Kaiser-Hill, 2002).

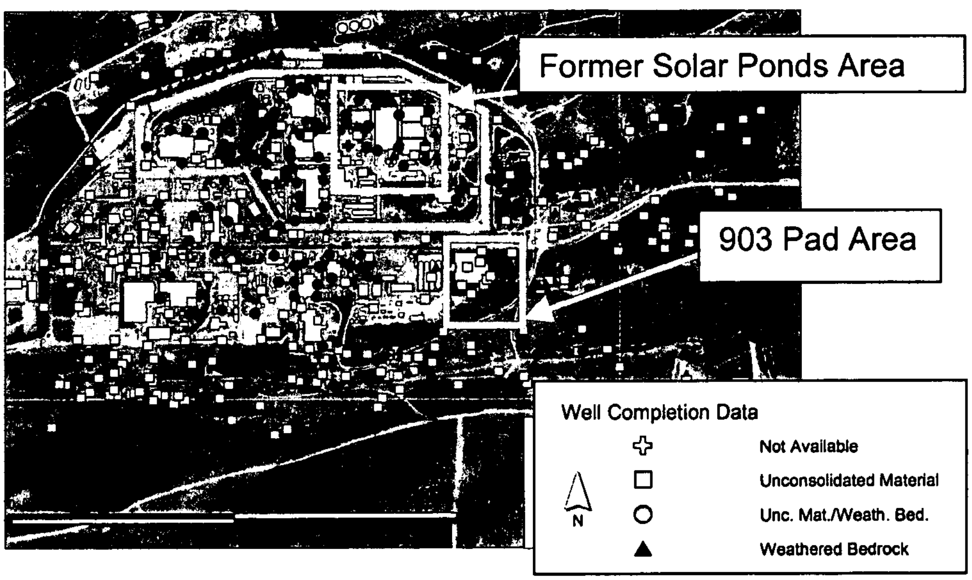

Figure 2.1. Locations of geologic borehole information. The symbols indicate the lowest formation penetrated.

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Figure 2.2. Depth to weathered bedrock (unconsolidated material thickness).

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Figure 2.3. Depth to unweathered bedrock (base of the mnaiodel).

2.2 Hydrologic Data

Groundwater level (head) data from quarterly water level measurements during WY2000 were used to constrain integrated flow modeling results. These data also were used to establish appropriate initial conditions for groundwater flow modeling. This time period was selected because of the quantity of groundwater level data. Gradients and flow directions modeled using these water levels were later used to evaluate contaminant transport with respect to possible source locations (Section 6). Figure 2.4 shows both continuous and quarterly monitored well locations where groundwater levels were collected during April, 2000.

Local drainage systems in the unconsolidated material affect the natural groundwater flow and made it difficult to accurately define groundwater levels in these localized areas without additional data. Near-stream areas were most important for calibrating seasonal groundwater discharge response within each VOC plume area. The lack of groundwater level information during early Site operations (i.e., 1950 to 1985) precluded reproduction of historical groundwater flow conditions at the Site.

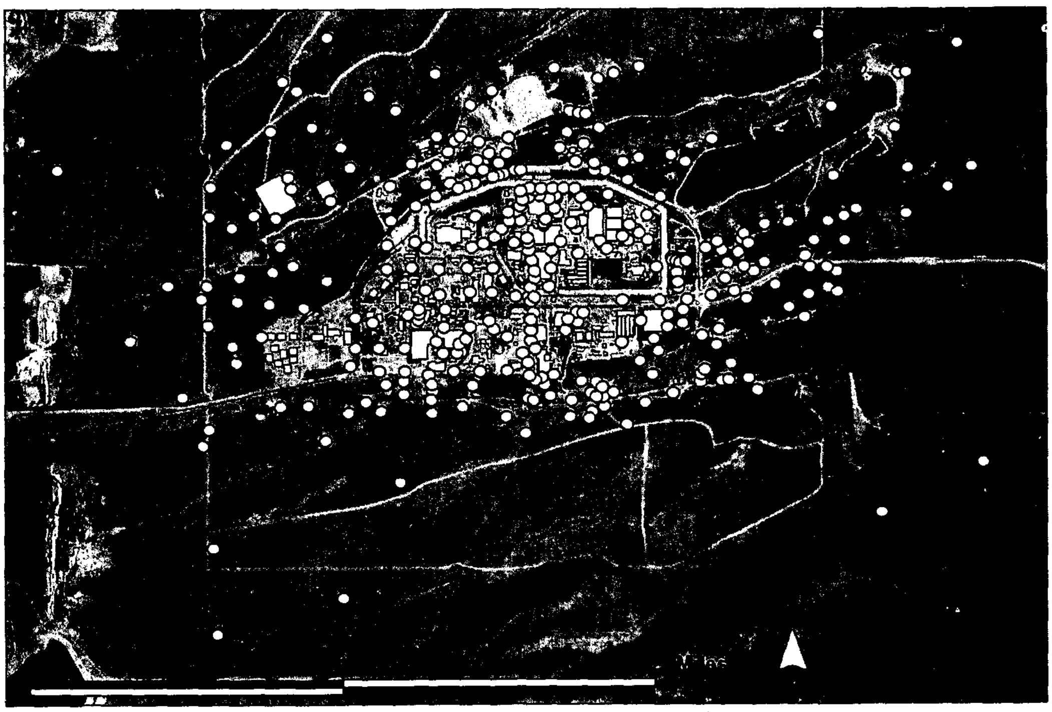

Figure 2.4. Locations of groundwater level data for April, 2000.

2.3 VOC Chemical Data

Site-wide water quality analysis results are compiled in the RFETS Soil Water Database (SWD). Based on the SWD, nearly 200 org anic contaminants were

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detected at the Site. Information on contaminant releases at RFETS was documented in a series of Historical Release Reports (HRR) prepared for the Site (DOE, 1992; DOE, 1993; DOE, 1994; DOE, 1995; Kaiser-Hill, 1996; Kaiser-Hill, 1997; Kaiser-Hill, 1998; Kaiser-Hill, 1999; Kaiser-Hill, 2000). At least 366 documented releases were reported, though, not all were associated with VOCs. A spatial GIS database of the documented releases and available historical VOC concentration data was developed to assist in developing a set of plumes and associated sources (Sections 2.3.1 and 2.3.2). The number of specific VOCs selected for modeling was systematically reduced to a manageable subset to assess the basic characteristics associated with historical and current plume distributions and movement (Section 2.3.3) and subsequent modeling (Section 6.0). Plots of groundwater VOC concentrations with time at sample locations through RFETS were constructed to identify temporal trends in plume behavior, or possible temporal trends in near-source concentrations (Section 2.3.4). Finally, the selected contaminants were compared with their draft surface water PRGs (Section 2.3.5) to determine which were most likely to impact groundwater concentrations at surface discharge areas.

2.3.1 VOC Source Database Development

Historical records of known or suspected chemical releases to the environment are documented in the HRR and summarized in Appendix A. These documents have been compiled annually or quarterly since 1992, and they represent the best known information of environmental releases at RFETS. Contaminant releases documented in the HRR date back to 1952, when Site operations began. Updated reports include new releases, as well as any additional information gathered regarding previous releases. In nearly all cases, there is no direct evidence indicating that HRR sources reached Site groundwater and can be tied to observed groundwater contamination. Therefore, for the purpose of this modeling effort, all sources in the HRR were considered potential VOC sources.

The HRR source information was entered into a GIS database to facilitate its use for this modeling project. The HRR and subsequent update reports were reviewed for any mention of a potential or verified release of volatiles, organics, solvents, chemicals, transformers, fuel, oil/grease, nitrates, PCBs, or process waste. These releases were entered separately into the database along with specific information about release timing, concentration, volume, composition, and cleanup.

The database entries were spatially referenced in GIS using Site coordinates reported in the HRR. Locations for many of the releases were uncertain (to within 500 feet). To locate possible VOC sources more accurately, Subject Matter Experts (SMEs) with expertise in the HRR information extensively reviewed the database. While uncertainty remains about exact locations of historical releases, the GIS database provided a SME-reviewed summary of published information that was readily queried and easily displayed.

The 366 entries in the database were classified as either Priority 1, 2, or 3 releases. A release was categorized as a Priority 1 release if a large volume (> 100 gallons) was documented, or if the release was considered significant by Site SMEs. Smaller releases (< 100 gallons) were categorized as Priority 2 releases. Very small releases considered insignificant (i.e., 0.5 gallon ethylene glycol spill in parking lot, cleaned up immediately), were classified as Priority 3 releases. Priority 1 and 2 releases were scrutinized during the review process. Priority 3 releases were not reviewed extensively given that the associated release volume was small and likely did not result in groundwater sources. Figure 2.5 shows the potential Priority 1 and Priority 2 release locations.

Despite efforts to compile all available information on releases into an all encompassing database, many significant data gaps and uncertainties remained. This release information was considered only as a guide in locating potential sources in the transport modeling effort. The significant uncertainties are recognized as a limitation in model development.

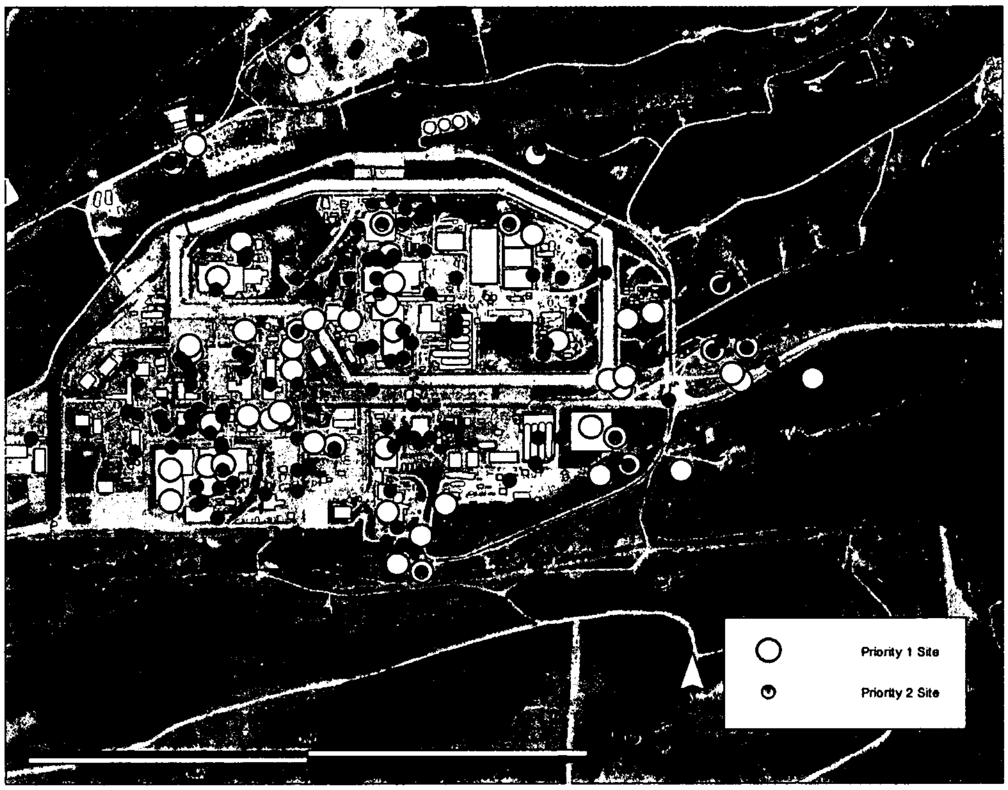

Figure 2.5. Priority 1 and Priority 2 release locations. A complete map correlating release sites with HRR information is included in Appendix A.

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2.3.2 Groundwater VOC Database and GIS

A digital database was developed to support both temporal and spatial analysis of the available groundwater VOC information at RFETS. The database was also used to develop groundwater VOC concentration time-series for analysis discussed in Section 2.3.4. Useful statistical information associated with time-varying groundwater concentrations were calculated in the database and subsequently used for spatially analyzing the distribution and trends of VOCs in groundwater using GIS techniques. Information from the digital database, the HRR release database, and approximate groundwater flow directions were systematically used to infer groundwater VOC source areas and the associated area, or areas of impacted groundwater.

The database was developed from an initial subset of 136,411 UHSU lab analytical records from the SWD database (provided by the SWD database manager). This initial subset included groundwater sample results for 36 analytes (including VOCs and supporting analytes such as Iron and Manganese), along with detection limits, Quality Control (QC) codes (duplicates), dilution amount, result value, and validation qualifiers for each sample. About 41,500 samples were lab detects. Non-detect sample results were retained in the database so that areas with no samples above the detection limit could be used to delineate areas with detectable concentrations. Duplicate sample results varied somewhat from the "real" sample results, but they were retained for averaging purposes.

The initial subset was refined using Microsoft Access to select only the highest risk VOCs, listed in Section 2.3.3. This subset of high risk VOC samples was exported to Microsoft Excel where time series for each VOC of each well were graphed along with detection limits to determine if there were any discernible trends and to generally evaluate the data consistency (Section 2.3.4). The dataset of high risk VOCs was then queried to select all samples that could be classified as "detect". Samples rejected by verification or validation were excluded as were samples where the result and detection limit were equal. Summary statistics were performed to determine the average concentration, minimum and maximum concentration, standard deviation, and number of detect and non-detect samples for each VOC at each sample location. Sample locations with at least one "detect" sample were included in the summary, and only the detect samples were used in the summary statistics. Non-detect samples were excluded because they are reported below the detection limit. A separate summary dataset of sample locations with all samples at or below the detection limit was compiled to help delineate areas with higher concentrations. The summary statistics for each of the sample locations was included in the GIS database to facilitate spatial/conceptual assessment.

2.3.3 VOCs Selected for Analysis

An initial subset of 10 VOCs (Table 2.1) was selected from the nearly 200 organic chemicals observed at the Site for further temporal analysis based on spatial distribution, frequency of sample detects, and sample concentration. This subset was cross-checked with the Site Water Program's list of VOCs of interest (as defined by inclusion in the former annual VOC composite mapping of the 2001 RFCA Annual Groundwater Monitoring Report) and all were on the list. These chemicals are all parent or daughter products of the PCE, TCA, and CCl_4 degradation chains.

Table 2.1. 10 VOCs selected from 200 chemicals in SWD for further evaluation (spatial lots and temporal trends).

Selected VOCs	Acronym
TETRACHLOROETHENE	PCE
TRICHLOROETHENE	TCE
cis-1,2-DICHLOROETHENE	cis-1,2-DCE
VINYL CHLORIDE	VC
1,1-DICHLOROETHENE	1,1-DCE
CARBON TETRACHLORIDE	CCl_4
CHLOROFORM	CCl_3
METHYLENE CHLORIDE	CCl_2
1,1-DICHLOROETHANE	DCA
1,1,1-TRICHLOROETHANE	TCA

2.3.4 Temporal Concentration Trends

The absence of increasing or decreasing trends at most sample locations suggests that most plumes are relatively stable configuration, implying that the source is also constant. If a plume was growing, the concentration at locations down-gradient from the source would increase with time. However, the usefulness of the sample dataset to detect trends was constrained by the limited time range over which sampling has taken place. Sampling was not initiated until

1986, long after most of the releases occurred in the 1950s and 1960s, apparently after most plumes had stabilized. If a plume was shrinking (i.e., a slug source), near-source sample concentrations would likely decrease with time.

The variability in sample concentrations (typical ranges between one and 1.5 orders of magnitude) is attributed to seasonal variations in groundwater levels (Figure 2.6). Clearly, other factors include daily variation, well completion, sampling, and sample analysis. This causes groundwater fluxes, and therefore, solute fluxes through source zones to vary in time. As a result, sample locations down-gradient of source zones reflect seasonally varying concentrations, but they have relatively steady long-term concentrations. Seasonal variability in sample concentrations with time could be attributed to variable spatial and temporal distribution of infiltration from ground surface (i.e., runoff, or precipitation) through sources within the vadose zone as well. Finally, it could be due to changes in source concentrations with time, or changes in source NAPL architecture, though, this probably would not account for the apparent seasonal variability in concentrations (i.e., variability might be more abrupt or not cyclic).

PCE chain concentration data for two wells (Figure 2.7) are shown on Figure 2.8 and Figure 2.9 as an example of data that shows no increasing or decreasing trend.

Steady (i.e., 1986 to 2003) concentrations also suggest VOC sources are likely constant, possibly indicating the presence of NAPL sources or back diffusion from stagnant zones. If sources do not have NAPL, or source volumes were small, a greater number of sample locations would probably exhibit decreasing concentrations with time.

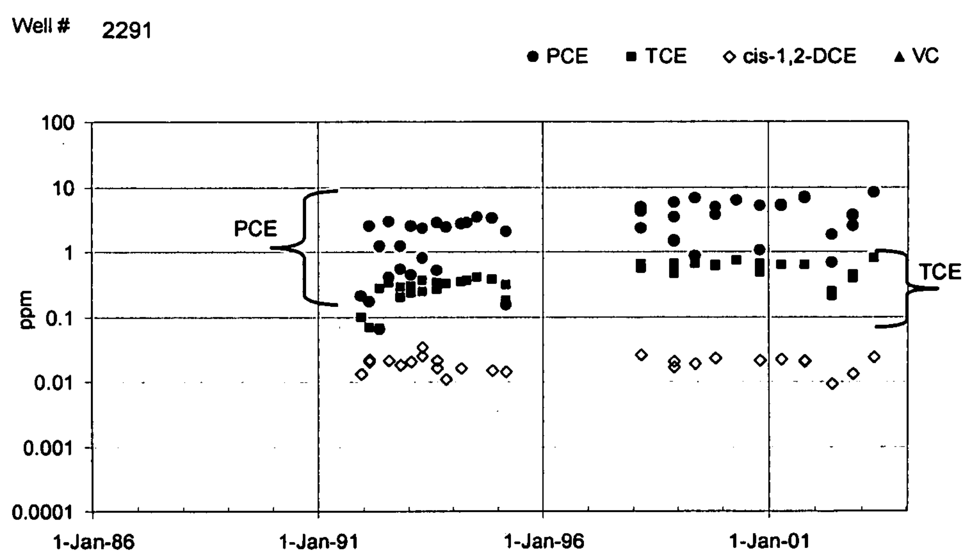

Figure 2.6. Concentration plot showing variability in sample results. Note that results vary about one order of magnitude.

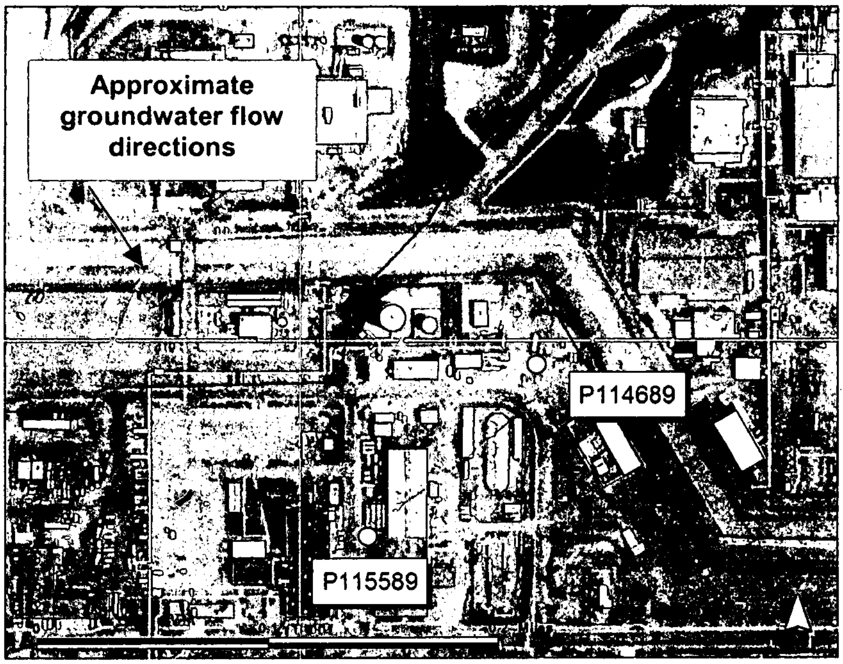

Figure 2.7. Well locations for data shown on Figures 2.9 and 2.10.

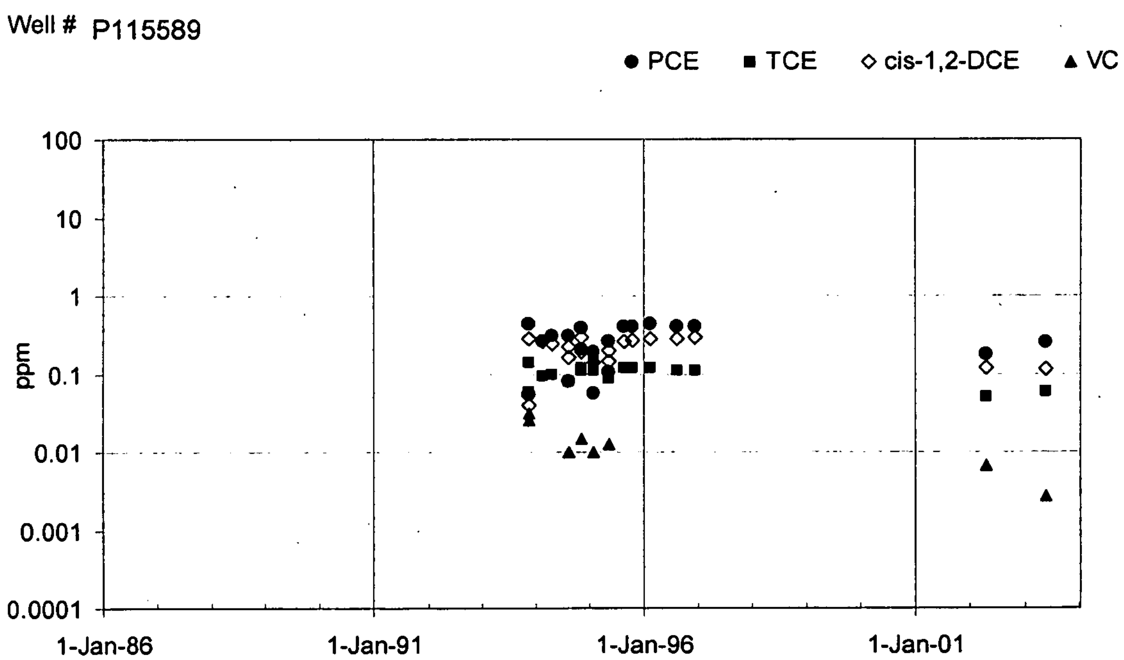

Figure 2.8. Sample concentration data (log scale) for well P115589 (location shown on Figure 2.7).

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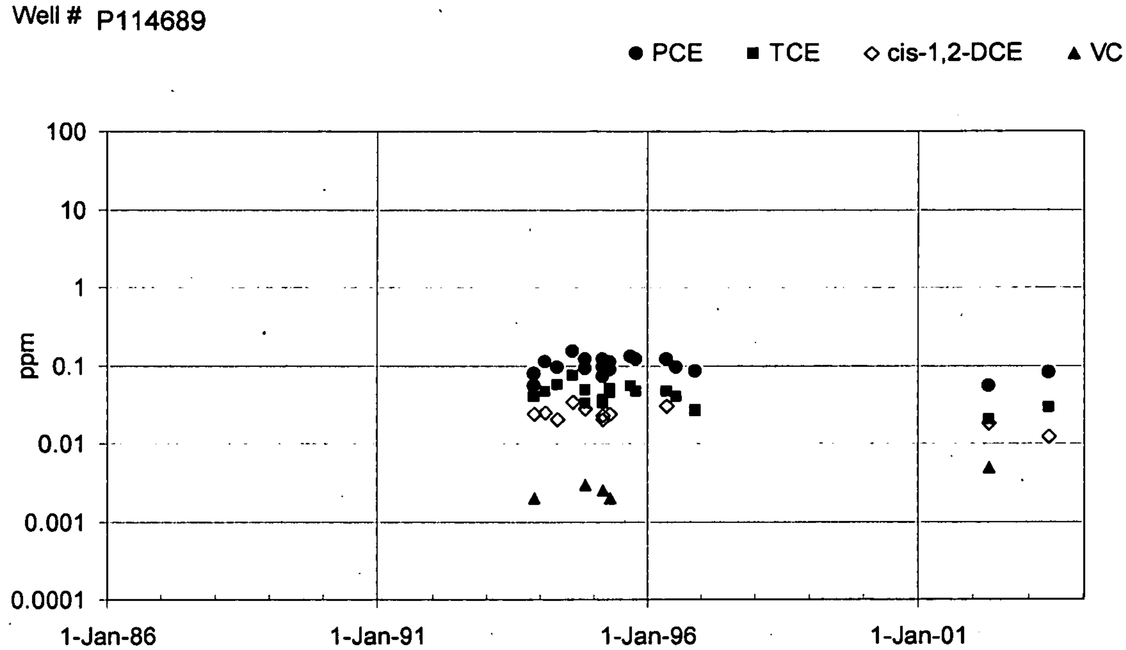

Figure 2.9. Sample concentration data (log scale) for well P114689 (location shown on Figure 2.7).

Well 3586 (located down-gradient of the Mound Groundwater Collection System) is an example of a well that shows a decreasing trend (Figure 2.10 and Figure 2.11). The concentration plot (Figure 2.11) suggests a localized TCE source that is diminishing over time and completely degrading to the daughter products (cis-1,2-DCE and VC). Small amounts of PCE were present with only one sample slightly over the detection limit. This contrasts with other wells [2291(Figure 2.12) and 897 (Figure 2.13)], which are near and far from the primary source in PSA 5 (Figure 2.10), that show no trends and have a higher concentration of PCE with successively lower concentrations of the daughter products TCE and cis-1,2-DCE.

Sample concentrations with time at most locations show no clear signs of increasing or decreasing beyond typical seasonal sample variability. For example, a sample taken after the wet season might be diluted by increased recharge, thereby giving a lower result than a sample taken during the dry season. Also, fluctuating groundwater levels can also produce variability in concentrations observed in sample locations, down-gradient from source locations. A cumulative density plot shown on Figure 2.14 summarizes the difference between maximum and minimum log concentrations for all VOC samples considered in this study for CCl_4, PCE, and TCE. Results confirmed that this difference for greater than 96% of the samples at the Site varies less than two orders of magnitude in time. In other words, most sample concentrations with time showed little to no clear increasing, or decreasing trends with time.

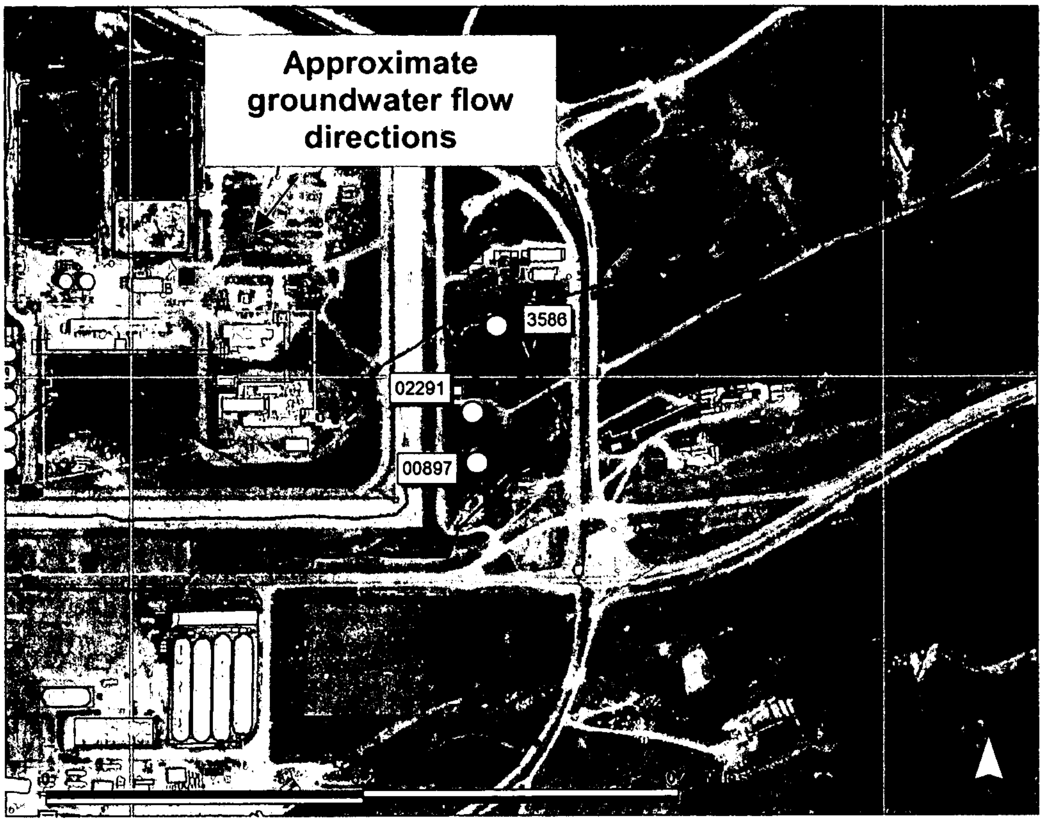

Figure 2.10. Well locations for data shown on Figures 2.11 through 2.13.

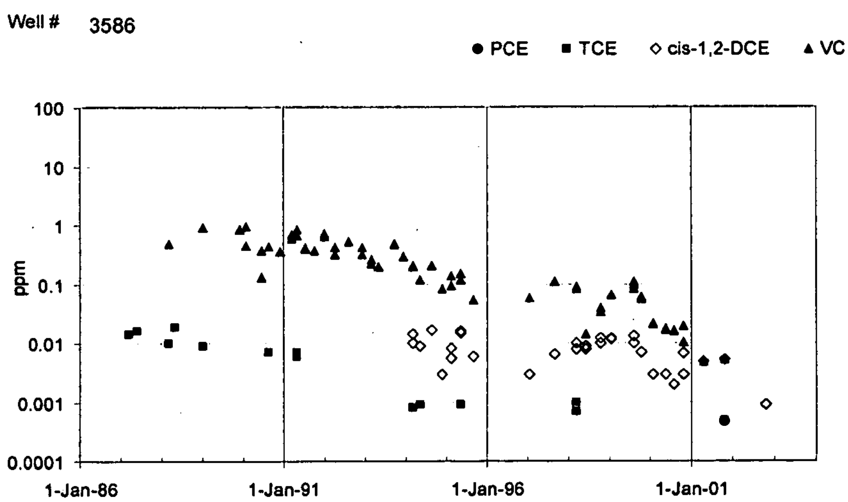

Figure 2.11. Sample concentration data (log scale) for well no. 3586 (location shown on Figure 2.10).

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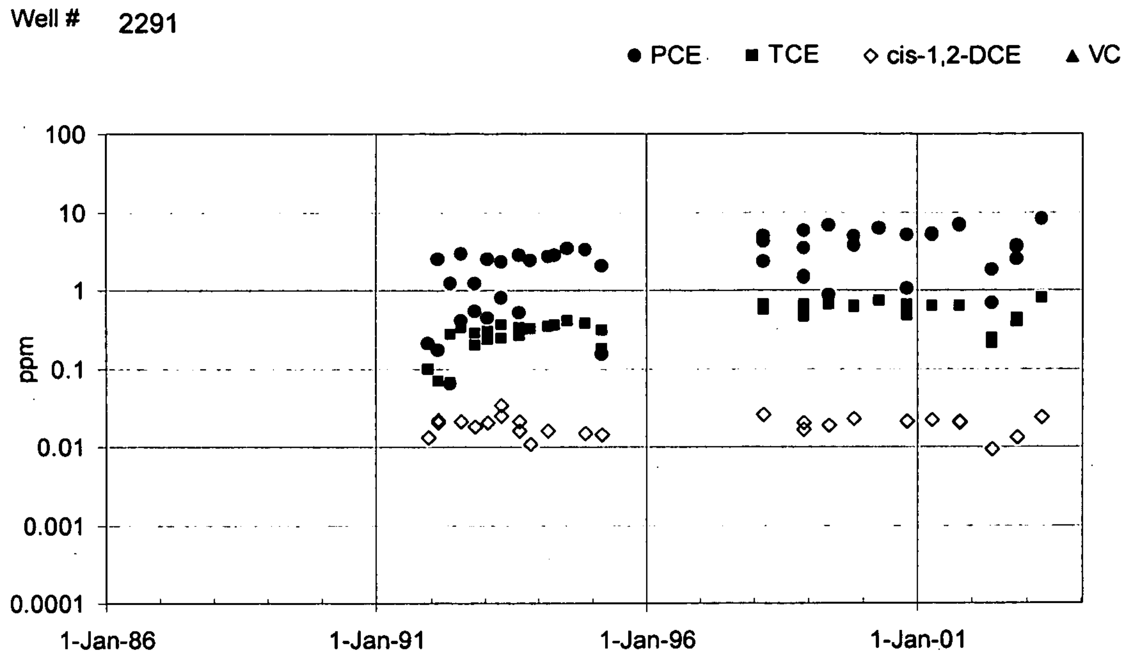

Figure 2.12. Sample concentration data (log scale) for well no. 2291 (location shown on Figure 2.10).

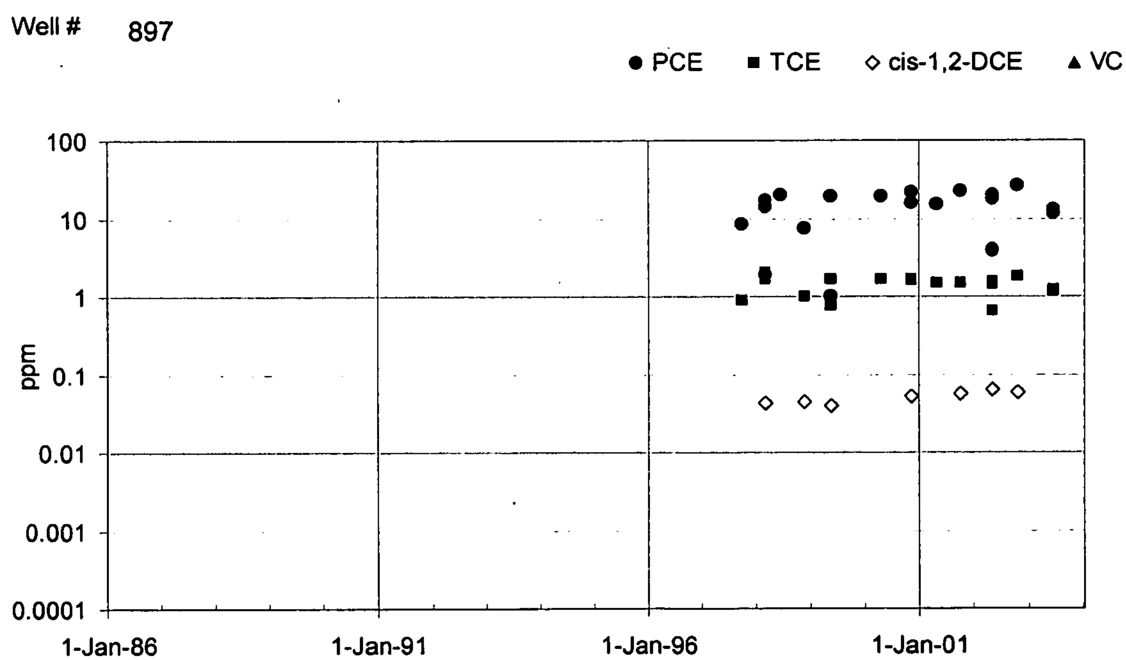

Figure 2.13. Sample concentration data (log scale) for well no. 897 (location shown on Figure 2.10).

Instead of attempting to reproduce the observed variability of concentrations in time at all sample locations, all historical concentration information, including recent 2003 well "snapshot" sampling data, were temporally-averaged. This approach was considered valid given the lack of clear increasing or decreasing trends in time (Figure 2.14) for most samples. An additional benefit to using time-averaged concentrations is that considerably more sample locations are available than would have been using only current "snapshot" data. This information is important because it is then used to constrain plume areas (described in Section 3.0), and parameter values in the reactive transport modeling discussed in Section 6.0.

Figure 2.15 shows the number of samples detected in time for TCE and associated degradation products. Results clearly demonstrate that individual years of data vary significantly (i.e., more than 100%). This is largely due to different historical sampling objectives. Moreover, it is important to recognize that the same wells sampled, for example, in 2003 were not, in many instances, the same wells sampled in earlier, like in 1995. Clearly, using data from only one year did not provide as clear a picture of where VOCs exist in groundwater as using all historical information. Finally, once VOCs were detected in a sample for the first time, subsequent sampling events typically showed detectable levels. This observation, along with the apparent steady concentrations, support using average time-averaged concentrations for delineating plume areas, and as performance criteria for later reactive transport modeling (see Section 6.0).

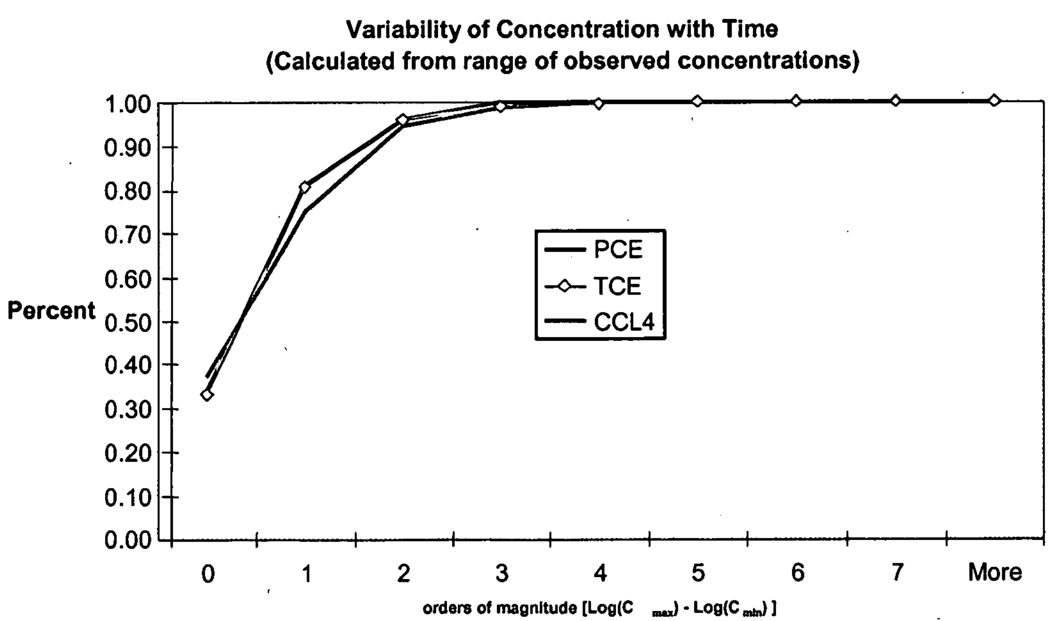

Figure 2.14. Cumulative plot of the number of sample locations whose concentration range falls within one or more orders of magnitude.

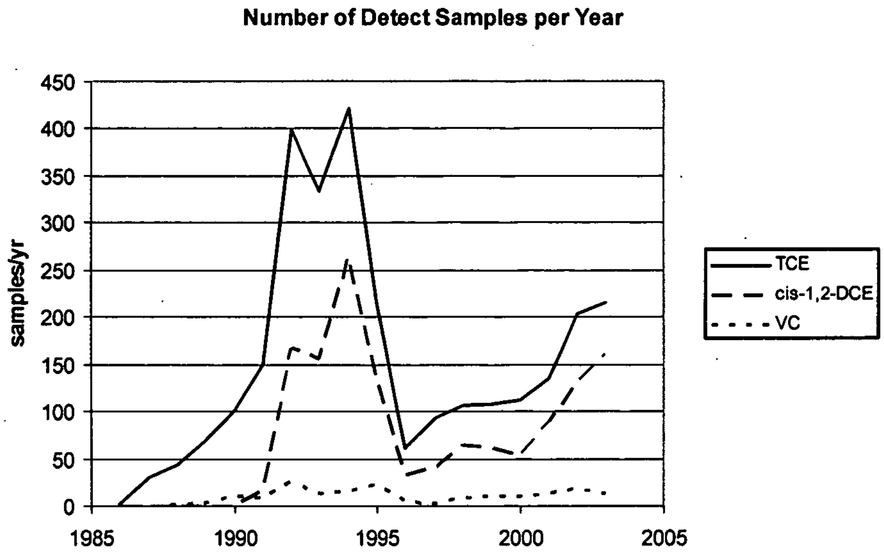

Figure 2.15. Plot of detected VOCs within the study area over the sampling time range.

2.3.5 Modeled VOCs

For each of the 10 VOCs considered (Table 2.1) maximum historical concentrations at all sampling locations (within each PSA) were used as the basis for determining whether individual PSAs fate and transport were evaluated further with modeling. Maximum historical concentrations in time were compared against proposed draft surface water PRGs (Table 2.2). Only PSAs in which maximum historical VOC concentrations were higher than draft surface water PRGs were modeled. If maximum historical concentrations were above draft surface water PRGs, it was assumed that inferred source area groundwater was capable of producing groundwater VOC concentrations in groundwater discharge areas that were also greater than the PRGs. As a result, if no historical maximum groundwater sample concentrations were above PRGs, they were not modeled.

Although the criteria used here reduced the total number of PSAs modeled, it was considered reasonable. For example, the combined attenuation effects of other processes such as biodegradation, dispersion, sorption and evapotranspiration act to reduce downgradient VOC concentrations before groundwater discharges to surface water. In addition, time-series analysis (Section 2.3.4) also confirmed that most sample location groundwater VOC concentrations are relatively stable in time, suggesting that it is not likely that the mostly decades-old inferred sources will produce higher VOC concentrations at existing sample locations in the future.

Therefore, only the PCE and CCl_4 degradation chains were considered for further fate and transport modeling evaluation. These chains are illustrated on Figure 2.16.

Table 2.2. Comparison of maximum observed data with PRGs (at hazard quotient = 0.1) (Chromec, 2002).

VOC	Max Observed Groundwater (mg/L)	Solubility (range of published values, temperature dependent) (mg/L)	Surface Water PRG (mg/L)	Observed above PRG?	Surface Water Standards (mg/L)	Selected for modeling?
PCE	528, 120 (well 0174)	130 – 400	1.46	Yes	0.0008	Yes
TCE	220 (well 3687,7391)	1000-1100	0.19	Yes	0.0027	Yes
Cis-1,2-DCE	2.9 (well 8891)	3500	18.25	No	0.07	Yes
VC	1.2 (well 33502)	1100-2790	0.105	Yes	0.002	Yes
CCl_4	100 (well 6691)	800	0.58	Yes	0.00025	Yes
Chloroform	64 (well 6691)	8000	20.3	Yes	0.0057	Yes
Methylene Chloride	43 (well 3687)	13000	10.1	Yes	0.0047	Yes
1,1,1-TCA	20	950 – 1500	568	No	0.2	No
1,1-DCA	5	5000	203	No	3.6	No
1,1-DCE	48 (well 0974)	2500	0.13	Yes	NA	No

PCE/TCE Degradation Chain

PCE (Tetrachloroethene)

↓

TCE (Trichloroethene)

↓

cis-1,2-DCE (Dichloroethene)

↓

VC (Vinyl Chloride)

Carbon Tetrachloride Degradation Chain

CCl_4 (Carbon Tetrachloride)

↓

CCl_3 (Chloroform)

↓

CCl_2 (Methylene Chloride)

Figure 2.16. Degradation chains for PCE and CCl_4.

The results of this comparison are shown in Table 2.2. Three of the 10 VOCs (TCA, DCA, and cis-1,2-DCE) did not pass the screening process. Cis-1,2-DCE was modeled even though its maximum concentration is below its surface water PRG, because it degrades to VC (as part of the PCE degradation chain) which was observed above its PRG. One of the chemicals, 1,1-DCE, was eliminated because of its limited occurrence (there are only eight wells with more than one sample greater than its draft surface water PRG) and that it occurs in areas already modeled with the PCE degradation chain. Based on these results, only the chemicals in the PCE and CCl_4 degradation chains were modeled. The time-averaged sample locations and concentration ranges for the seven VOC analytes in the PCE and CCl_4 degradation chains are shown spatially in Appendix B, Figures B-1 throgh B-7.

3.0 CHARACTERIZATION AND CONCEPTUALIZATION OF FLOW AND TRANSPORT

Many factors affect the fate and transport of VOCs in groundwater at RFETS. The purpose of this section is to describe key factors and how they affect VOC fate and transport.

Key processes controlling plume migration include: advection, degradation, sorption, ET / volatilization, and dispersion. As groundwater flows past a contaminant source, the contaminant dissolves into the groundwater at a rate dependent on the solubility of the chemical. The plume front advances down-gradient primarily by advection from the source. Factors affecting advection are described in Section 3.2. The remaining processes generally attenuate plumes, creating high concentration distributions near the source that diminish away from the source. These processes were systematically evaluated for VOCs throughout the IA and to the east for the first time at RFETS in the context of plumes and sources within a groundwater flow field. In this approach, an attempt was made to associate likely plume areas to possible VOC sources. This is described in more detail in Section 3.3.

3.1 Approach

A description of the VOC plume characteristics and their sources required a detailed spatial and temporal evaluation of all available groundwater observed VOC concentration data coupled with the major factors influencing fate and transport. At RFETS, the fate and transport of VOCs in groundwater within the IA is complex and likely affected by many factors. Past studies and interpretations of available data suggested that the most important factors controlling VOC transport at RFETS include:

- advective transport with groundwater flow, the dominant mass transport process in groundwater flow systems. It is a strong function of groundwater flow directions and velocities that are controlled by the heterogeneity of the formation and influenced by many factors (Section 3.2);
- source locations, depths, release times, and effective concentrations; and
- other fate and transport processes associated with fate and transport of dissolved constituents (e.g., dispersion, biodegradation, and sorption).

Four steps were taken to understand observed distributions of VOCs in groundwater at RFETS. First, the groundwater flow field was determined so that advective transport directions and velocities could be evaluated. Second, areas impacted by VOCs were clearly identified. This step required evaluation of all time-varying groundwater concentration data, mostly from wells throughout the IA. The third step was to identify the most probable sources for the observed

VOC distributions. In this step, HRR information was used to infer groundwater VOC sources. Finally, areas in which groundwater was impacted by VOCs were then associated with these inferred VOC sources (Section 3.3).

Previous work at the Site [Annual Rocky Flats Cleanup Agreement (RFCA) Groundwater Reports] involved plotting the distribution of Tier I and II VOC concentrations in composite VOC maps. This approach does not utilize both groundwater flow paths and inferred VOC source areas in delineating plume concentration distributions and extents. In addition, no attempts were made to define areas with groundwater VOCs down to detection levels. As a result, these composite plume maps could not be used to as the basis for simulating fate and transport from inferred VOC sources.

Previous work did not evaluate the fate and transport of individual VOCs. Differences in chemical properties of individual VOCs cause differences in their fate and transport behavior. Temporal and spatial characteristics of the individual VOCs provided basic information on sources, areas where degradation occurs, degradation rates, and differences in transport (typically resulting from differences in chemical properties of individual VOCs). Finally, observed concentration distributions of individual VOC daughter compounds served as constraints on several parameters in reactive transport modeling.

A step-wise approach was developed to evaluate the spatial distribution of individual VOCs in groundwater using available time-averaged groundwater VOC concentration data. A discussion of areas where groundwater is impacted by VOCs is described in Section 3.3 below. A new term, Plume Signature Areas (PSAs), was introduced to refer to the distinct areas of impacted VOCs as suggested by time-averaged historical observations. A PSA represents a single plume or a number of plumes associated with a single source or a combination of sources in the same vicinity. General characteristics of PSAs are summarized in Section 3.3.2, while characteristics of VOC sources are described in Section 3.3.3.

3.2 Factors Affecting Groundwater Flow

Advective transport of contaminants with the groundwater is usually the most important factor in VOC transport modeling. The groundwater flow field must be accurately simulated to effectively model the transport of VOCs to discharge areas. The conceptual model developed for the integrated SWWB flow model (Kaiser-Hill, 2002) was adequate for explaining most factors that affect flow within the IA, but not those affecting VOC fate and transport. This section focuses on the factors that affect transport flow paths and velocities under current conditions and under the proposed closure configuration. Key factors include the following:

- subsurface pipelines;

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- subsurface utilities and utility corridors;
- subsurface structures;
- groundwater collection systems;
- unconsolidated material types and their distribution;
- weathered bedrock surface;
- unweathered bedrock surface;
- Arapahoe Sandstone distribution;
- impervious areas (buildings/pavement); and
- vegetation distribution.

These factors are described in detail below.

Subsurface pipelines

Subsurface pipelines occur primarily in the more industrialized parts of the IA. They remove groundwater from the local areas, with the exception of the water supply pipelines. Subsurface pipelines are more important in areas of higher pipe densities (i.e., western IA and Central Avenue) and less important in lower density pipe areas, like the 903 Pad area. For example, flow modeling in the Building 771 area showed that subsurface drains impacted the local groundwater flow regime and likely the contaminant distribution observed in the area. Proposed deactivation of these subsurface pipelines will cause a local increase in water levels, which may change local VOC concentrations.

Subsurface Utilities

Backfill material associated with subsurface utilities may also influence local flow and hence advective transport. The backfill material (whether the excavated material or coarse sand/gravel) at the base and around utilities is believed to be more permeable than surrounding unconsolidated or bedrock material. As such, if water levels rise into this material, they can behave as preferential pathways for flow and VOC transport. The quantity and locations of available wells near known utility corridors was insufficient to clearly demonstrate their effects on transport.

Building Footing Drains

Building footing drains currently act as strong hydraulic controls around deeper building basement structures. However, in the proposed closure simulations, footing drains were assumed inactive. As a result, subsurface building basement structures may act as barriers to flow, rather than as local groundwater discharge points. Local groundwater VOC concentrations may change as a consequence of the deactivation of footing drains, for example, around Building 771.

Groundwater Collection Systems

The current gravity drainage systems were designed to collect contaminated groundwater in their vicinity. The proposed land reconfiguration modification will not likely impact the operation of these systems. No new systems were considered in this modeling effort.

Unconsolidated Material Distribution

Unconsolidated materials within the Integrated VOC Flow Model area are predominantly Rocky Flats Alluvium (Qrf), Artificial Fill (af), and to a lesser extent, colluvium, and landslide deposits (Qc and Qls, respectively). Little information was available on af properties, but it is assumed that af is roughly similar to Qrf (with possible screening of larger rocks – this would result in possible higher storage). Closure conditions assumed that the af material is used in re-graded topographic areas (see Section 6.1.4). The hydraulic properties of these materials strongly control groundwater velocities and pathways. The distribution of surface soils also controls the spatial and temporal distribution of recharge and ET throughout the integrated VOC Flow Model area.

The seasonal fluctuation of groundwater within the unconsolidated material is another important factor that strongly controls the transport of VOCs. The higher hydraulic conductivity of the unconsolidated material relative to the underlying weathered bedrock allows groundwater to flow more rapidly in the unconsolidated material. However, in areas where the groundwater level fluctuates above and below the unconsolidated material and weathered bedrock interface, average groundwater flow velocities and paths become complex. At times when the high conductivity unconsolidated material is saturated, flow and transport are relatively rapid. However, when the unconsolidated material is unsaturated, flow is restricted to the lower conductivity weathered bedrock. This condition of variable saturation occurs mainly in hillslope areas, particularly to the north, east, and south of the IA (within the integrated VOC Flow Model domain).

Depths to Weathered Bedrock and Unweathered Bedrock

Groundwater flow paths are strongly influenced by the conductivity of the different geologic units at the Site. Accurately estimating locating the contacts between the unconsolidated material, weathered bedrock, and unweathered bedrock was essential to developing an accurate flow model layers. Simulations of groundwater flow direction are directly dependent on the accuracy of the mapped units because of the contrast in hydraulic conductivity values for the three units. Maps of the depth to weathered bedrock and the depth to unweathered bedrock are shown on Figure 2.2 and Figure 2.3.

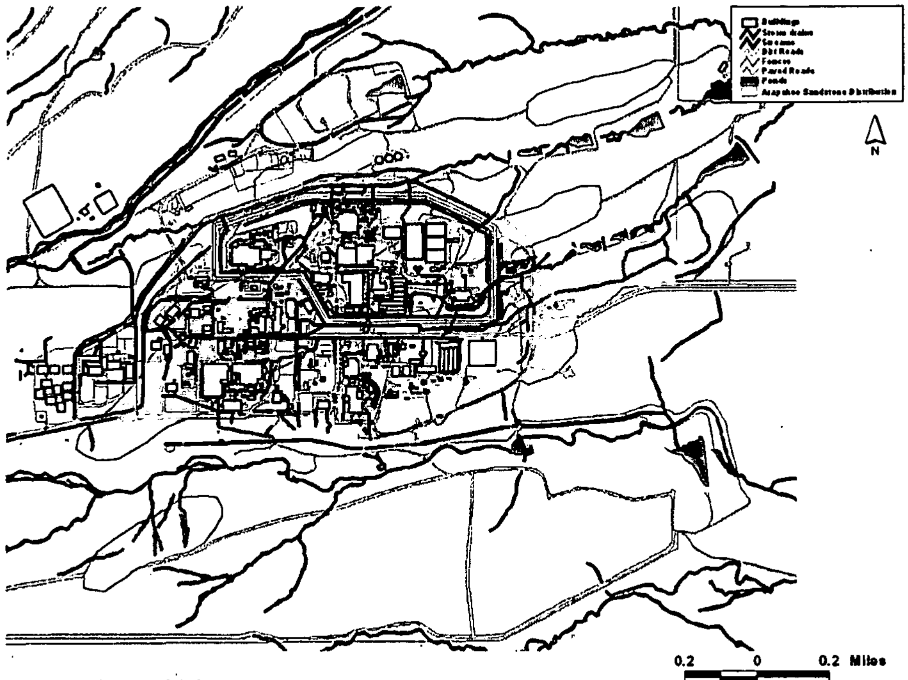
The weathered bedrock (claystone/siltstone) hydraulic conductivity is from about 10 to 300 times lower than the overlying unconsolidated material. Because of its relatively high conductivity, the majority of flow occurs within the unconsolidated material when it is saturated. In some locations (such as the IA plumes near Building 771, Building 991, and the 903 Pad) the unconsolidated material is less than 5 feet thick and on average, unsaturated. This occurs in the east-central part of the IA, where groundwater flows to the east from the 903 Pad area in a relatively thick, saturated zone of unconsolidated material along the topographic high before diverging down-gradient to the north and south.

The interpolated weathered bedrock surface was prepared for the SWWB model (Kaiser-Hill, 2002). The 903 Pad area flow divergence is consistent with the bedrock surface, and it is also influenced by the Arapahoe Sandstone in the area.

Arapahoe Sandstone Distribution

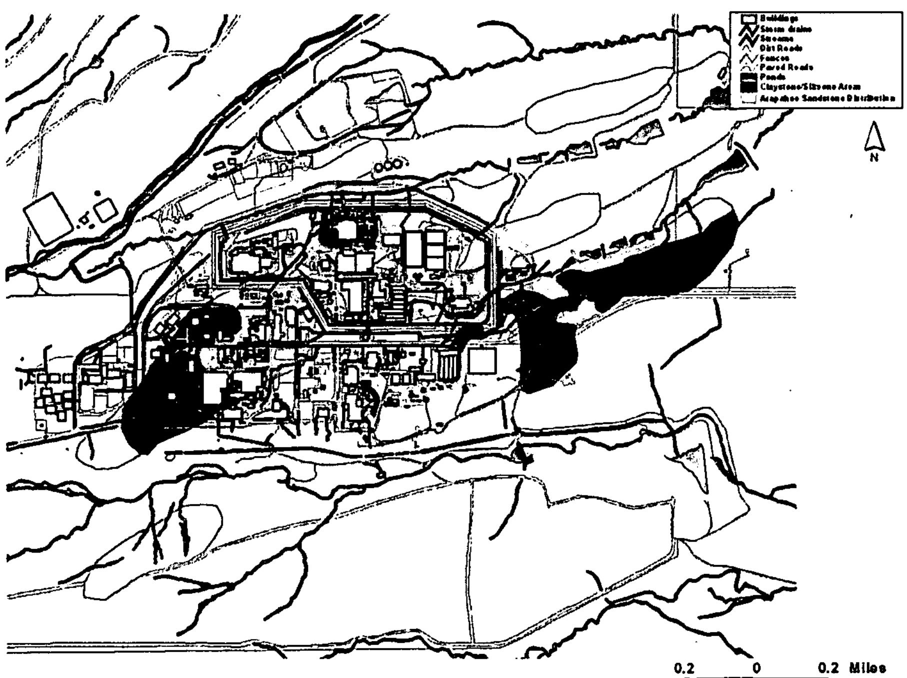
The shallow distribution of Arapahoe Sandstone within the UHSU has a strong influence on local groundwater flow paths and velocities. The modeled distribution of sandstone is shown on Figure 3.1, while the areas that subcrop the unconsolidated material are shown on Figure 3.2. The dark areas on Figure 3.2 represent areas where claystone/siltstone weathered bedrock material overlie the Arapahoe Sandstone (Arapahoe Sandstone does not subcrop the unconsolidated material). The discontinuous sandstone occurs in several areas impacted by VOCs, specifically the 903 Pad area, central IA, former western Solar Ponds area, the Mound Groundwater Collection System area, and Building 771. Its high permeability, compared to the surrounding weathered bedrock siltstone/claystone matrix, causes groundwater to preferentially flow towards it, and within it. The degree to which these act as preferential conduits depends on its discharge at seeps. The presence of numerous seeps throughout the Site is attributed to its subcropping beneath thin unconsolidated material along hillslopes (EG&G, 1995a). Discharge at seeps cause the shallow sandstone lenses to dewater, which in turn causes local groundwater to flow towards and within the sandstone.

The occurrence and configuration of the Arapahoe Sandstone within the UHSU weathered bedrock also impacts the local fate and transport of VOCs in groundwater. Although the Arapahoe Sandstone occurs within each of the primary VOC plume areas, it subcrops (occurs in the upper weathered bedrock) near the Building 771, Building 991, Mound System/Oil Burn Pit, East Trenches, and former Solar Pond areas (Figure 3.1 and 3.2). VOC sources introduced in areas where Arapahoe Sandstone subcrops (e.g., the East Trenches) probably results in deeper sources (i.e., at base of Sandstone) because the permeability of the sandstone is similar to the unconsolidated material. In addition, the distribution of Arapahoe Sandstone, where continuous, causes preferential pathways for VOCs, because the sandstone permeabilities are much higher than the surrounding UHSU weathered bedrock (claystone/siltstone) material.



Revised from EG&G, 1995a Report

Figure 3.1. Distribution of the Arapahoe Sandstone.



Revised from EG&G, 1995a Report

Figure 3.2. Subcropping Arapahoe Sandstone areas.

Impervious Areas

Impervious areas are important under current conditions because they prevent direct recharge, but promote much higher localized recharge where runoff occurs in adjacent pervious areas and limit direct ET losses. This is an important aspect of the integrated model in predicting accurate groundwater flow paths. The seasonality of this recharge process likely causes significant local divergence of flows from "recharge mounds" at the edge of impervious areas, which may be one cause of the macro-dispersion of plumes.

Vegetation

Vegetation distributions within the IA control local ET rates and hence the net recharge to a given area. Near streams, ET is the dominant groundwater discharge mechanism. The SWWB modeling estimated that more than 90% of the annual precipitation is lost to ET. Additionally, the rate of ET loss increases as groundwater depths decrease or as you approach stream areas. The loss of VOCs to ET may be a dominant process at RFETS. This process alone may limit the migration of VOCs to adjacent stream areas as baseflow. In arid/semi-arid areas like RFETS, ET strongly controls the water levels at stream areas, and if it is strong enough, no baseflow ever occurs.

Faults

Geologic fault lineaments across the Site have only been inferred and not specifically studied or mapped (EG&G, 1995). With the currently available information, these faults do not appear to influence groundwater flow or VOC transport at the Site.

3.3 Plume and Source Characteristics

Developing a good understanding of the basic characteristics of dissolved VOC distributions and their possible sources was essential to constructing a realistic and acceptable flow and transport model of the IA at RFETS. The extent to which this can be done depends largely on the quality and quantity of available data. At RFETS, although source data and time-averaged concentrations are inherently uncertain, it is still possible to prepare meaningful interpretations by synthesizing information from available data. Several steps taken to describe the basic characteristics of recent VOC distributions and their sources are discussed below.

3.3.1 Plume Signature Areas

PSAs are defined as distinctly separate areas where groundwater is impacted by VOCs. Within these areas, there is at least one probable VOC source, though in most cases there are several. In many cases, multiple source locations (or a single source location with multiple source releases in time) produce co-mingling

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groundwater plumes with complex concentration distributions that are generally indistinguishable from each other with available groundwater well water quality information. The PSA shape, extent, and concentration distributions are developed using available groundwater flow paths, groundwater VOC concentrations (from wells), and HRR information.

PSAs were developed for several purposes summarized below:

- clarification of the spatial distribution of VOC-impacted groundwater within the IA;
- evaluation of parent-daughter VOC spatial relationships;
- identification of individual VOC distribution trends;
- evaluation of individual VOC distributions in groundwater given different chemical properties (different chemical properties allow each VOC to travel and degrade differently in groundwater);
- identification of possible locations where dissolved VOCs may have been introduced from entrapped NAPL or back diffusion from stagnant zones (referred to as source locations);
- understanding of constraints on flow and transport model parameterization using PSA concentration distribution and extents;
- temporal analysis of concentration trends within specific PSAs emphasizing basic source concentration characteristics. For example, constant concentration trends in time in all observation wells within a given PSA suggest that source concentrations are likely to remain constant; and
- development of initial concentration distributions in closure configuration simulations to predict a range of maximum groundwater discharge concentrations.

PSAs were developed for the 10 most spatially frequent VOCs detected in groundwater throughout the IA using the GIS-database described in Section 2.3.3. Of these VOCs, only seven remained after screening with draft surface water PRGs (Section 2.3.5). The seven remaining VOCs represent the degradation chains for PCE and CCl_4, suggesting that these VOCs are likely the most common VOCs in source areas.

The extent of each PSA was defined using plots of historical time-averaged groundwater sample concentrations (Appendix B, Figures 1-7) in conjunction with available groundwater level information and inferred groundwater flow directions (Section 2). The delineation of a PSA is based on the following: (1) a continuous area with average concentrations at or above 10 ug/L and with at least one sample location with an average concentration above the draft surface water PRG; (2) a potential source location; and (3) groundwater flow directions based on integrated modeling of WY2000 data. Figure 3.3 and Figure 3.4 show boundaries only for PSAs that are modeled. PSAs in which historical maximum VOC concentrations are less than the surface water PRGs (included on Figures 1 to 7 in Appendix B) are not modeled.

Initially, an attempt was made to differentiate areas with detectable levels of VOCs from areas with no detectable levels for any sampling event. In this step, major PSA areas were identified. In some PSAs, it was difficult to associate observed VOC concentrations at some data locations because of plume commingling of multiple sources. More careful evaluation of historical releases, discussions with SMEs, and spatial evaluation of concentration distributions within preliminary PSAs allowed for further refinement of individual shapes and likely source areas. In developing the PSAs, a GIS database was constructed that also supported transport modeling (average and maximum concentrations, number of data points, potential source locations, estimated travel distances, and estimated distances from groundwater discharge areas). Significant data gaps and uncertainty were also noted in preparing the PSA maps.

Although PSAs represent the best understanding of VOC groundwater distributions, external boundaries were based on professional judgment. As such, the spatial shape and extent of PSAs are only used to evaluate the spatial characteristics VOC distributions within the IA. Ultimately, flow and transport modeling was used to refine the extents and pathways for VOCs. In the transport modeling discussed later in Section 6.0, only the concentration data at observed locations are used to constrain calibration of flow and transport parameter values. General PSA characteristics are discussed next in Section 3.3.2.

3.3.2 PSA Characteristics

The data used to develop PSA boundaries provides significant conceptual insight into VOC contamination of groundwater at the Site. General characteristics of the individual VOC PSAs are described here.

Biodegradation is likely, given consistently observed daughter product distributions, and appears to occur through most of the PCE and CCl_4 chains. All PSAs with PCE signatures contain TCE and DCE, and most contain VC. As further evidence of biodegradation, all of the PSAs being evaluated contain cis-1,2-DCE (considered to be an indicator compound for biodegradation). In some PSAs, degradation to lower chain compounds is limited. For example, VC did not occur in all areas with detectable levels of PCE or TCE. This suggests that local conditions may not be anaerobic enough to fully degrade parent compounds to lower VOC compounds. Alternatively, conditions may be highly aerobic, causing the VC to be completely degraded from the system.

Figure 3.3. PCE/TCE Chain. General PSA locations are based on the presence of analytes at or above the draft surface water PRG. Boundaries are based on a conservative value of 10 ug/L time-averaged well concentration. VC is present in most PSA areas, but is not displayed because of its limited spatial extent.

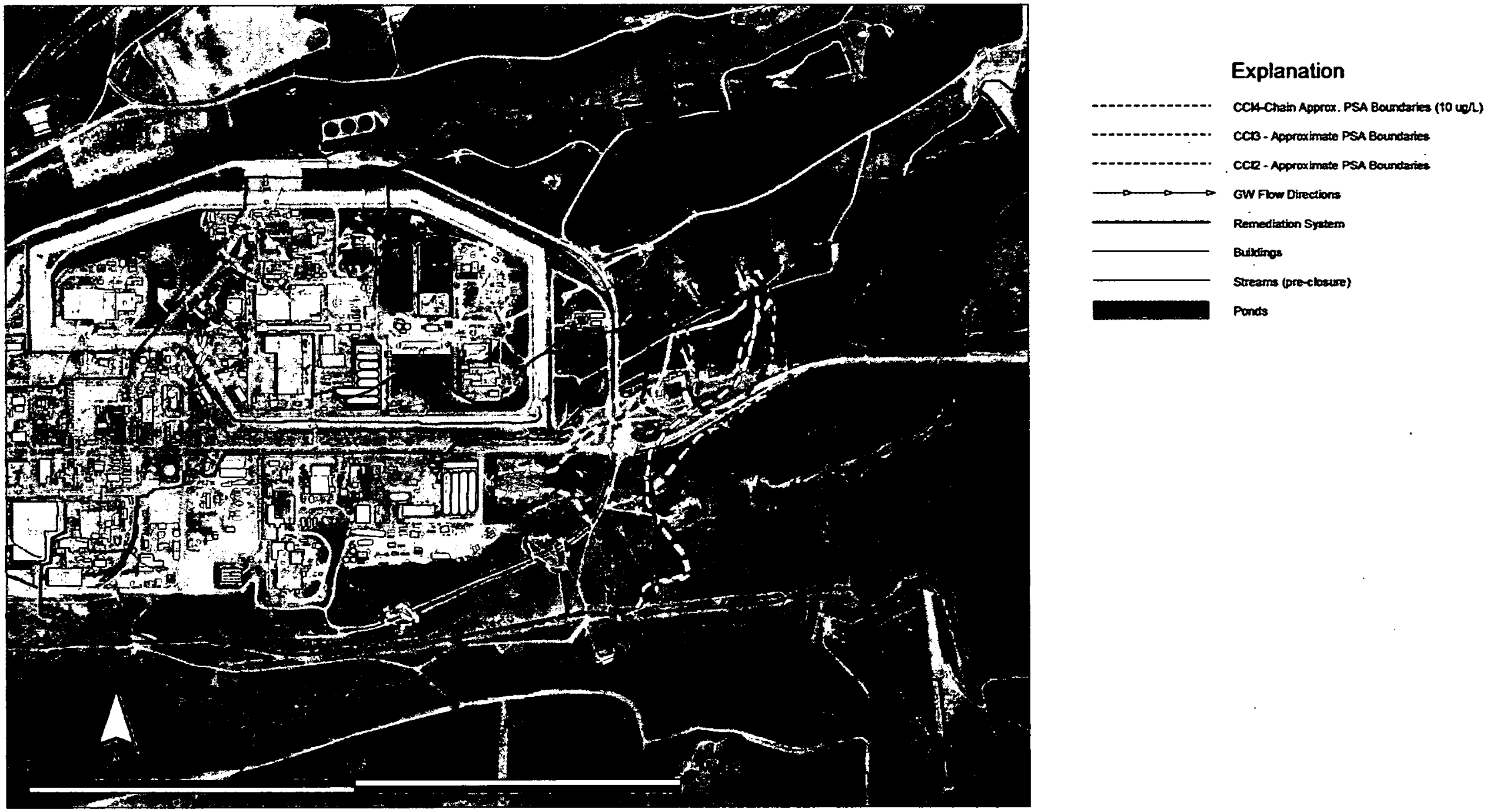

Figure 3.4. CCl_4 Chain. General PSA locations are based on the presence of analytes at or above the draft surface water PRG. Boundaries are based on a conservative value of 10 ug/L time-averaged well concentration.

Areas identified as PSAs are generally reasonable given groundwater flow paths, concentration distribution, historical release information, and probable groundwater discharge areas. Detectable levels of VOCs are found mostly within unconsolidated material, though this may be somewhat biased by less sampling done within the weathered bedrock. Concentrations increase in the bedrock relative to the unconsolidated material within some areas of the Site (East Trenches area), probably due to the occurrence of Arapahoe Sandstone.

Most PSAs appear to extend to groundwater discharge areas (i.e., streams, seeps, or ponds). Concentrations are generally low in these areas (<100 ug/L). The lack of discernable changes in concentration trends with time suggests increasing ET losses as groundwater nears stream areas may limit its movement. Stream VOC data is generally lacking to confirm this point.

Groundwater VOC distributions do not appear to be strongly affected by subsurface drains. For example, if drains were to affect transport significantly, concentration distributions would likely reflect linear trending high-density subsurface drain features. PSA shapes and concentration distributions do not clearly show this trend. Though, in some instances such as building footing drains, VOCs have clearly been detected. Moreover, it is difficult to fully assess this with limited well resolution around these features. Subsurface utility trench effects on the distribution of VOCs are also difficult to assess with the resolution of available well data. However, no strong correlations are evident between high-density subsurface utility corridors and PSA distributions.

VOC source areas occur mostly within upper, mesa areas where Rocky Flats Alluvium is prevalent. In most source areas, multiple VOCs are present. This implies that source releases involved multiple VOCs, rather than a single VOC parent product. HRR information also supports this finding. For example, VOC daughter products were probably introduced as the primary source, though this is less likely for degradation products, such as cis-1,2-DCE.

Individual PSA extents and their likely source locations suggest that VOCs have traveled similar distances. This implies several things:

- groundwater VOCs were introduced at similar times;
- hydraulic properties for hydrogeologic units (unconsolidated material and weathered bedrock) are similar; and
- similar attenuation processes act on the plumes.

Differences between individual VOC PSA extents did not appear significant. This suggests that differences in the transport of different VOCs due to their chemical properties may be less important than advective transport (i.e., groundwater flow paths and velocities).

Sampling result information for the VOCs is presented in Table 3.1. All VOCs except VC was detected in more than 150 wells with PCE and TCE detected in 327 of 621 wells.

Most well records did not indicate a clear increasing or decreasing concentrations in time. While concentrations vary in these "no-trend" wells, this variability is likely due to seasonality, or slow system response to periodic recharge events.

Table 3.1. Number of wells with at least one sample above detection limit for analytes of interest. All listed analytes were detected in all PSAs modeled.

VOC	Number of Wells Showing Detection	Number of Wells Sampled
PCE	327	621
TCE	327	621
Cis-1,2-DCE	201	557
VC	44	620
1,1-DCE	152	621
CCl_4	218	621
CCL_3	257	621
Methylene Chloride	265	619

3.3.3 VOC Source Characteristics

The GIS database of HRR releases (Appendix A) contains 363 entries. Of these potential sources, 15% are identified as Priority 1 releases, 70% are identified as Priority 2 releases, and 15 % are identified as Priority 3 releases. As discussed in Section 2.3.1, most solvent releases were only indicated generally, without identifying the specific type or the composition of spilled solvent or mixtures. In the few cases where specific solvents were noted, the following six VOCs were identified: PCE, TCE, cis-1,2-DCE, CCl_4, Chloroform, and Methylene Chloride (six of the seven VOCs being considered for modeling).

HRR release information did not provide information on the composition of VOCs. In most cases, release volume, spill area (source configuration), and duration are uncertain and therefore had to be evaluated through modeling.

For each of the PSAs which passed the screening process, the number of potential VOCs sources within or adjacent to the PSA area varied significantly (from 0 to 15). Priority 1 and Priority 2 release locations are shown previously on Figure 2.8. The source release time periods in the database range from 1951 to 1998. The database indicates that most of the larger releases occurred in the earlier years of Site operation.

3.4 Data Gaps

Thirteen wells were added to address data gaps identified following initial delineation of individual VOC PSAs (Figure 3.5). Four of the wells are located in the Ryan's Pit area southeast of the 903 Pad. Two wells are located west of the Mound area and were used to sample near the former Oil Burn Pit. One well is located in the East Trenches area down-gradient of a potential source with no other nearby control. Three wells were located in the PSA 13 area and were used to assess the presence of VC in this area.

Not all of the sampling information obtained from these new wells was used to constrain modeling results. However, where available, results of sampling were used to improve conceptual flow and transport and subsequent modeling efforts. Specifically, information from the Mound Groundwater Collection System area and south of Building 371 were used in this study.

3.5 Flow and Transport Conceptual Model

The conceptual flow and VOC transport model is described in this section. It was developed using information derived from the characterization of groundwater flow (Section 3.1) and plume and source distributions (Section 3.2). Conceptualizing the flow and transport emphasized the essential features and processes that must be incorporated into the numerical model. Key features and processes that influence the fate and transport of VOCs to groundwater discharge areas are graphically illustrated on Figure 3.6. A brief description of each process and feature is described in terms of how it impacts VOC transport.

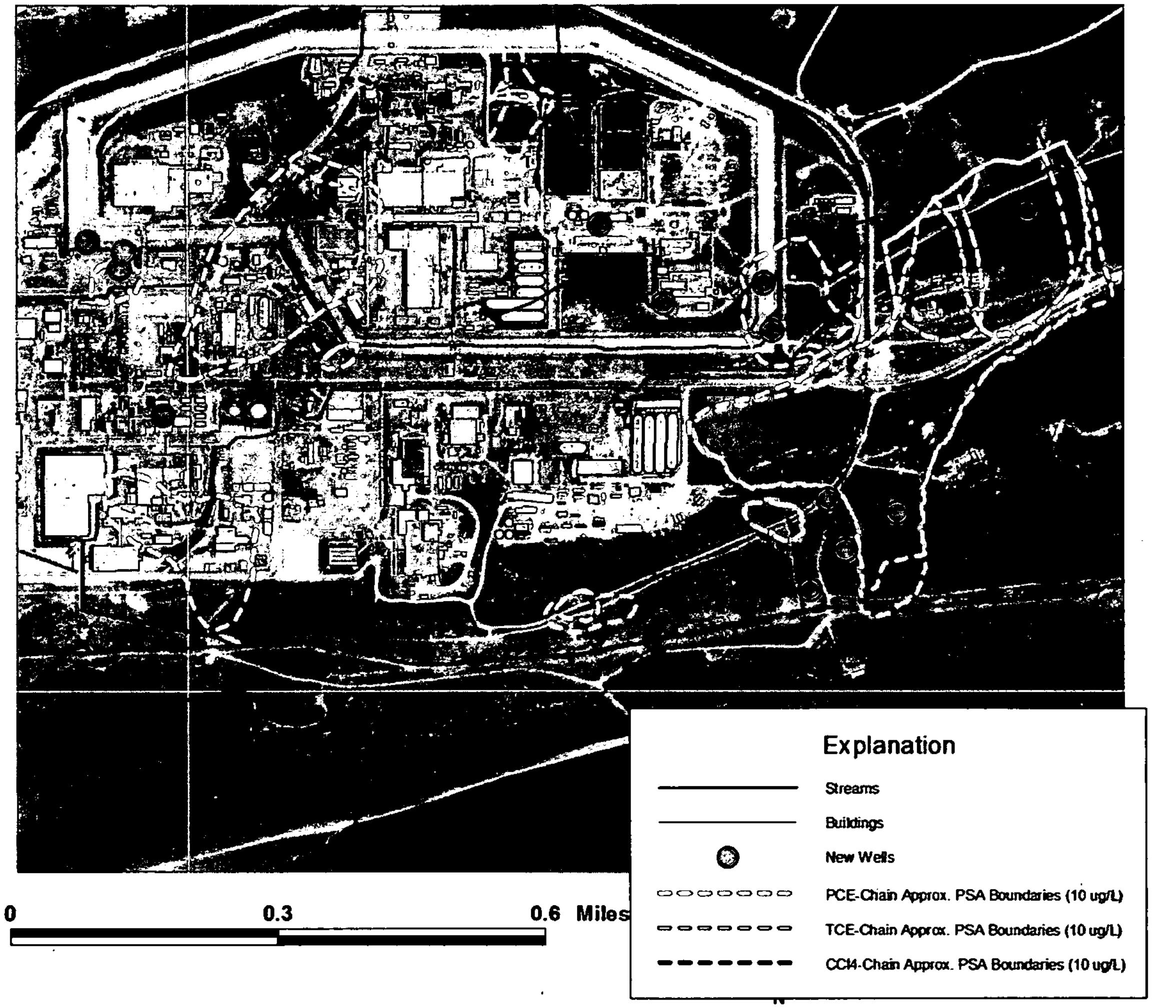

Figure 3.5. New wells installed to address data gaps.

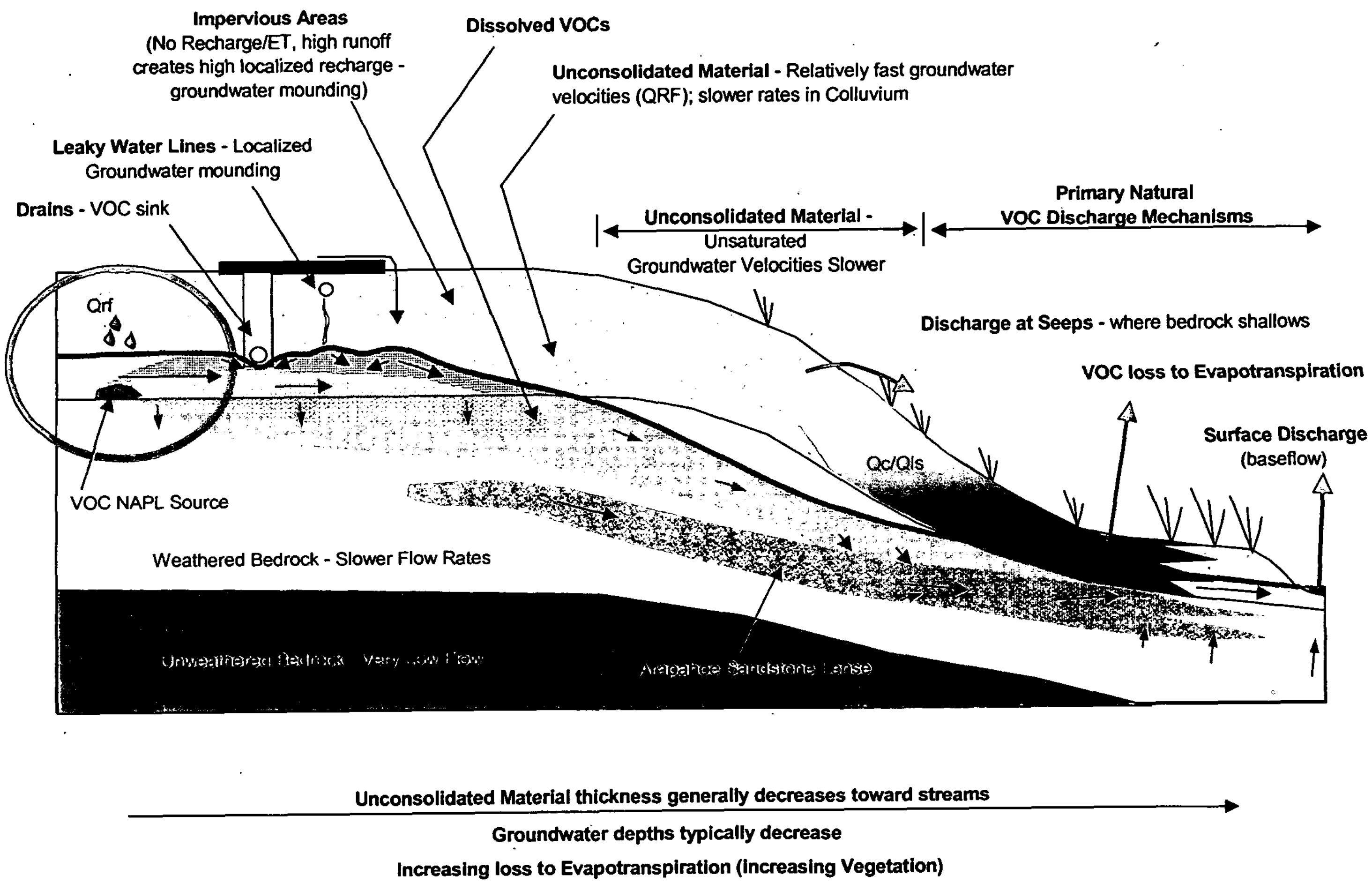

Figure 3.6. Conceptual flow and transport model.

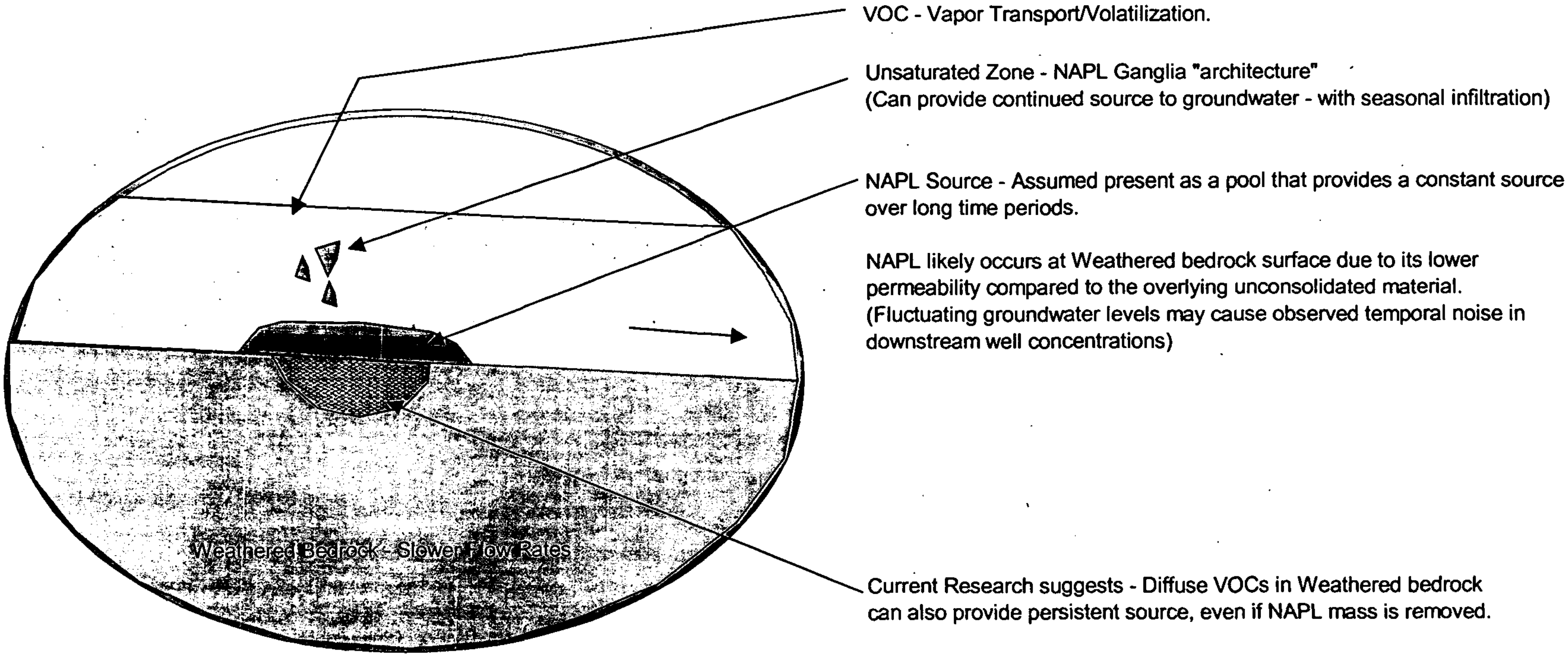

Figure 3.6. (continued) NAPL conceptual diagram.

The conceptualization of groundwater flow was extensively documented in the SWWB modeling (Kaiser-Hill, 2002). Key Site features and subsurface hydrogeologic factors affecting flows were described in detail in Section 3.1. Most of these features are described on Figure 3.6. Groundwater flow within the IA at RFETS is dominated by the hillslope structure. Direct precipitation, infiltration, localized run-on from impervious areas, or leaky water supply lines recharge groundwater throughout the upper mesa areas of the model domain. This generally causes a slight downward vertical gradient from the unconsolidated material into underlying weathered bedrock. Although groundwater flows from upper mesa areas to nearby stream areas, some water is lost via ET even in areas well below the root zone (i.e., caused by unsaturated zone moisture deficits within the root zone).

As groundwater moves within the model domain, it can be affected by subsurface drains in two ways: (1) actual discharge (or recharge) to pipelines like storm or sanitary sewers; or (2) by subsurface utility trenches which may preferentially route water within associated permeable backfill material. As groundwater flows from mesa areas down through hillslope areas, levels can decline into the weathered bedrock due to seasonal fluctuations, thinning unconsolidated material, increased ET effects, and increased lateral drainage (i.e., increased hydraulic gradients). This causes groundwater velocities to decrease due to lower bedrock hydraulic conductivities. In some areas, the presence of Arapahoe Sandstones causes groundwater to flow preferentially within these deposits. As groundwater nears lower hillslope areas, or near-stream areas, vertical gradients typically reverse and are directed upwards. Groundwater is either lost to ET or baseflow, though previous integrated modeling indicates that the majority of loss is via ET along lower hillslope areas where groundwater levels are shallow. Groundwater can also discharge to the surface at surface seeps during higher precipitation periods.

The occurrence of VOCs is probably due to the presence of NAPL caused by either spills, or leaks from pipelines, or buried wastes. NAPL source occurrence in the RFETS hillslope conceptual flow model is described on the second diagram for Figure 3.6. Due to the greater densities of NAPLs compared to groundwater NAPLs migrate vertically downward until reaching a relatively stable pool, typically caused by a lower conductivity material. At RFETS, the weathered bedrock contact likely acts as such a contact, though, locally, greater NAPL source volumes might be driven into the weathered bedrock to greater depths. Recent research also indicates that where high NAPL volumes exist above hydrostratigraphic contacts, the NAPL can migrate into the underlying lower permeability material via diffusion.

As the NAPL travels from the source area, it is also possible that residual amounts remain in the unsaturated zone. As groundwater passes through NAPL areas, dissolved concentrations develop within the groundwater at the NAPL/water interface. Seasonal fluctuations in groundwater levels can increase the flux of dissolved VOCs passing through NAPL source zones. In addition, groundwater passing through residual NAPL zones within the unsaturated zone may also provide a persistent source of VOCs into the groundwater.

Once VOCs are dissolved in the groundwater, they become subject to different fate and transport processes. These processes include advective transport, degradation, adsorption, dispersion, diffusion, groundwater discharge, and plant uptake (or transpiration). Much of the current VOC distributions throughout the IA are due to advective transport. Advection is typically a dominant process controlling VOC distribution and movement in groundwater. This emphasizes the need to accurately reproduce groundwater flow paths and velocities.

VOCs in groundwater are also subject to dispersion effects. The dispersion of VOCs occurs in three dimensions. Typically longitudinal dispersion is greater, along the principal advective pathway. It accounts for differences in hydraulic properties within the primary hydrostratigraphic units, which are assumed homogenous at the cell-scale. In addition, seasonal fluctuations of localized mounding within the IA due to runoff from paved areas probably causes increased macro-dispersion of VOCs.

VOCs can also be adsorbed onto the porous medium through which they travel. This causes concentrations in the groundwater to decrease, though over time, adsorption rates may decline and effectively this process may only retard the transport of higher concentrations from constant sources. Diffusive processes are typically small, at the scale of the VOC plumes. Their effects can become larger relative to dispersive effects in lower velocity areas, like weathered bedrock.

Biodegradation through anaerobic degradation (reductive dechlorination) is yet another way that concentrations of individual VOCs can be reduced as the VOCs in groundwater migrate towards discharge locations. At RFETS, however, available information suggest that biodegradation rates are likely low (Kaiser-Hill, 2004). Despite this, PSA characteristics (Section 3.2.3) strongly suggest that it does occur. Therefore, as parent VOCs (i.e., CCl_4, PCE, or TCE) migrate towards discharge points, their concentrations decrease, while daughter product concentrations tend to increase. Available data suggest that daughter products, such as VC, probably aerobically degrade. This implies it is possible that a VOC chain can entirely degrade before it discharges to the ground surface.

As groundwater nears stream areas, the effect of ET increases dramatically, due to shallower groundwater levels and increased vegetation. It is likely that VOC losses via ET are also significant, though direct evidence is limited (i.e., VOC concentrations within the vegetation canopy have not been measured). Moreover, ET losses are only high during warmer months, implying that groundwater discharge concentrations could be higher during colder months depending on local flow conditions.

4.0 INTEGRATED FLOW MODEL DEVELOPMENT

The development and application of an integrated groundwater-surface water flow model for current and a proposed closure configuration is described in this section. This integrated flow model was developed to simulate local flow conditions in PSA-specific areas, using a smaller model area and more refined grid than the original SWWB model (Kaiser-Hill, 2002). It was only necessary to model the saturated zone flow as accurately as possible to meet objectives as discussed in Section 1.1. This is because the distribution and fate of VOCs in groundwater at RFETS is strongly controlled by advective transport (i.e. see Section 3.3.2 on PSA characteristics). The original SWWB model, developed to evaluate Site-wide hydrologic response to proposed closure, encompassed a larger area, but grid discretization (200-foot by 200-foot) was too coarse for simulating fate and transport.

Advective transport of VOCs in groundwater at RFETS is strongly dictated by local flow dynamics within the UHSU. SWWB flow modeling showed that local groundwater flow paths and velocities at RFETS are complex and depend on many factors and processes. For example, surface flow and unsaturated zone recharge dynamics caused by seasonal changes in climate produce complex three-dimensional saturated zone flow paths. This in turn strongly influences the movement and distribution of VOCs. As a result, it was necessary to develop a saturated zone flow model that explicitly incorporated the complex external stresses, had the capability of simulating the three-dimensional flow, and predicted areas and rates of groundwater discharge.

The integrated hydrologic code MIKE SHE, used to develop the SWWB model (Kaiser-Hill, 2002), is a powerful tool for simulating the complex three-dimensional saturated zone flow. This computer code couples the surface-subsurface flow dynamics and also considers external stresses like the spatial and temporal distribution of climate factors. Available system response data that capture the integrated behavior of the system (i.e., time-varying stream flows, groundwater levels, and surface groundwater discharge with time) can constrain model parameter values more effectively than traditional single process models (i.e., MODFLOW simulation of only saturated zone). As a result, the integrated model produces more confidence in parameterization of key model input such as hydraulic conductivity.

A more localized and refined fully distributed, integrated hydrologic model was constructed for the area impacted by VOCs using the MIKE SHE code (Kaiser-Hill, 2002). This model is herein referred to as the "integrated VOC flow model" because it differs from the former SWWB Model. Its development serves two purposes. First, it is used to simulate current and closure configuration three-dimensional saturated zone flows that are used in subsequent VOC transport predictions. It also represents a tool that can be used to evaluate the hydraulic and hydrologic impacts of land configuration modifications and their affect on VOC transport.

Although some of the input for the SWWB model could be used directly in the integrated VOC flow model, most required direct conversion from the original GIS coverages. This conversion consisted of an automated comprehensive, multi-attribute spreadsheet algorithm. The spreadsheet was developed to streamline development of more refined integrated modeling input datasets (i.e., building-scale models). The spreadsheet algorithm generated model input in a consistent and easily manipulated format. This is important given the substantial amount of data that must be read into and out of the integrated code. The algorithm permitted changes to key parameters, such as specific geologic materials (i.e., Rocky Flats Alluvium or Colluvium), or specific drain leakage coefficients (i.e., sanitary, storm, footing drain, or water supply) to be incorporated directly into model input quickly and consistently.

The model boundary and discretization used in the current and proposed closure configuration integrated flow models are described first, in Section 4.1. Next, the development, application, and results of integrated flow modeling of current conditions are described in Section 4.2. The development, application, and results of integrated flow modeling of the closure configuration are described, in Section 4.3.

4.1 Model Boundary and Discretization

The integrated VOC flow model developed here differs from the original SWWB model in two ways. First, the areal extent of this model is smaller than the SWWB model. The model boundary and grid discretization of the IA flow model are shown on Figure 4.1. Only groundwater areas currently impacted by VOCs, or areas possibly impacted due to the closure configuration, were considered. Although VOCs in the PU&D Yard area were not included in this model, a separate integrated flow model developed for the Present Landfill system was used as the basis for simulating the three-dimensional groundwater flow in this area (Kaiser-Hill, 2004).

The integrated VOC flow model is also discretized differently than the SWWB model. Instead of using a 200-foot by 200-foot grid to represent groundwater flows, a more refined grid of 60-foot by 60-foot is used. The increased grid refinement better resolves local features, which was necessary to more accurately simulate transport. This is important because the transport of VOCs is sensitive to how accurately hydrologic features, such as building basements, pavement, drains, and other features are numerically represented. In addition, a more refined grid permits more accurate specification of source locations and effective source concentrations that can significantly affect transport of VOCs.

The vertical discretization of the saturated and unsaturated zones of the current model is the same as in the SWWB modeling (Kaiser-Hill, 2002). The saturated zone is divided into four model layers; the upper two layers represent the unconsolidated material, while the lower two represent the weathered bedrock. Two layers were defined for each of these UHSU hydrostratigraphic units to account for variable depths to subsurface utility corridors and building basements, and for the distribution of Arapahoe Sandstone within the weathered bedrock. The first saturated zone layer was defined as deep, as possible to better represent effects of ET from the unsaturated zone, but is adjusted locally to represent drain inverts. The third layer is adjusted locally to account for the presence of Arapahoe Sandstone, which can immediately subcrop the unconsolidated material, or be entirely embedded within the siltstone/claystone matrix.

4.2 Integrated Flow Model – Current Conditions

4.2.1 Model Configuration

The distributions of hydraulic properties in the integrated VOC flow model are mostly derived in the same fashion as for the SWWB model (Kaiser-Hill, 2002). Various spatial GIS datasets for the subsurface pipelines, utilities, surficial geologic materials, vegetation, pavement, and building coverages, and of Arapahoe Sandstone distributions were used as the basis for developing equivalent numerical representations for input to the model. A series of GIS techniques were used to convert the spatial information into a set of regularly spaced points. This information was then incorporated into the spreadsheet, where a set of algorithms are used to convert this information into appropriate MIKE SHE model input arrays.

Although, hydraulic properties for the different geologic material (i.e., unconsolidated material or bedrock) were not adjusted much from the SWWB model, the grid refinement required hydraulic conductivities associated with local subsurface drain cells to be refined. In addition, drain leakage coefficients also required adjustments in response to the refined grid.

The surface channelized flow routing also required adjustment in response to the grid refinement. The simulated channel network for the integrated VOC flow model is also shown on Figure 4.1. For example, although the SID is included in the model, Woman Creek to the south is not explicitly defined. Instead, effects of groundwater discharge to Woman Creek are simulated using constant head boundaries. The surface routing at the eastern end of Central Avenue and surface routing from the Building 774 area east to a storm drain that flows north into Walnut Creek were extended to better represent channelized flow in these areas.

4.2.2 External Stresses

- External stresses imposed on the integrated flow model are similar to those applied on the SWWB model. These are summarized in more detail in the SWWB modeling report (Kaiser-Hill, 2002). External stresses in the model include: (1) spatially uniform, but temporally variable, temperature with time

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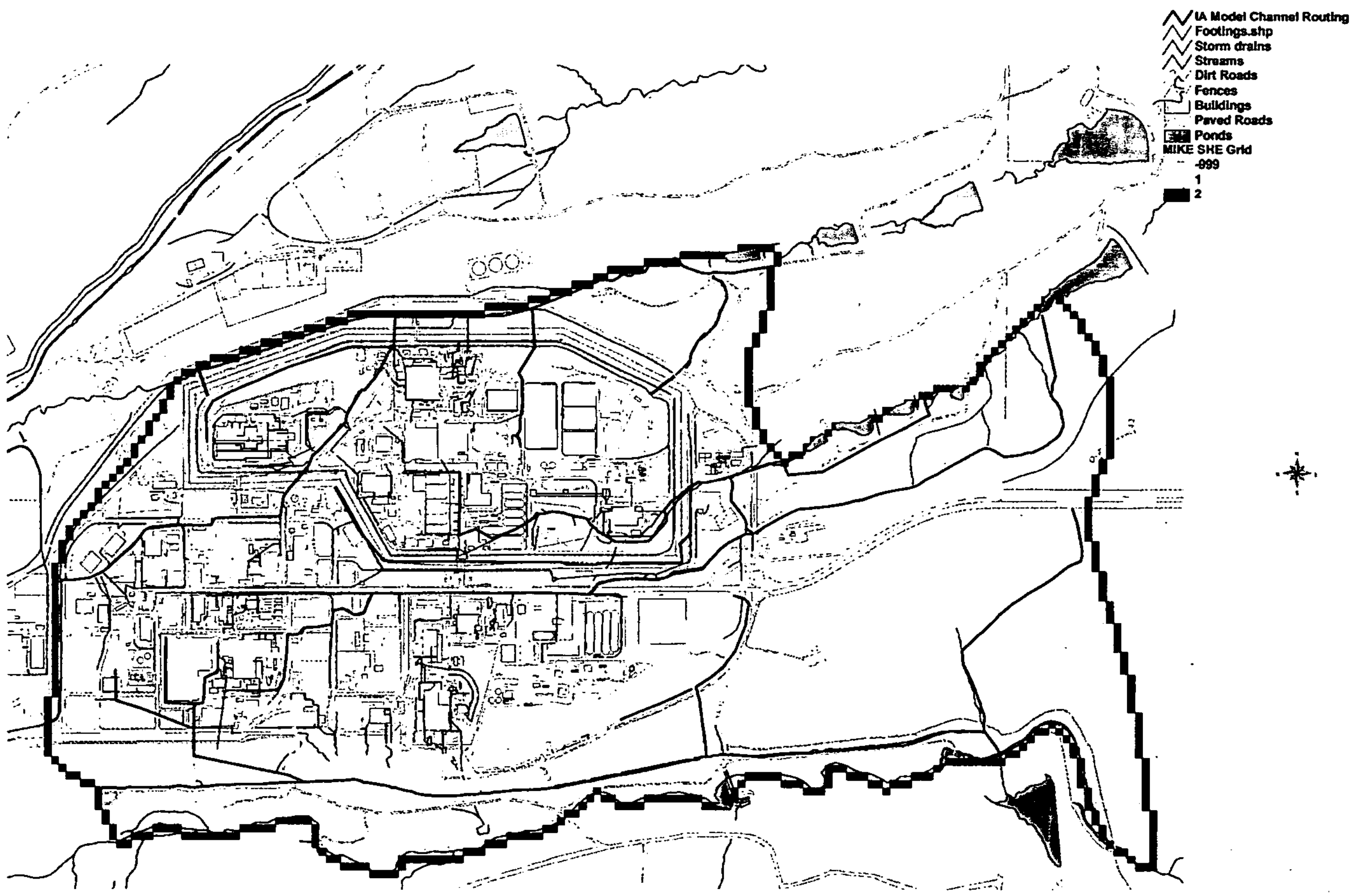

Figure 4.1 Integrated VOC flow model boundary and discretization.

(hourly); (2) potential ET (hourly); and (3) spatially and temporally variable precipitation (15-minute intervals).

Appropriate lateral boundary conditions are applied to the overland surface flow boundary and saturated zone. Overland flow boundaries were chosen such that no significant sources of overland flow are possible across them. As such, a zero-flux boundary condition is imposed along these overland flow boundaries.

Boundary conditions for all four layers of the saturated zone were specified as constant head. These boundaries for the integrated VOC flow model were specifically located to minimize impacts to flow calculations in internal areas of interest and to also represent realistic external boundaries (or external stresses). For example, constant head cells along Woman Creek to the south coincide with this feature because it represents a groundwater flow divide. Boundary conditions were simulated here as constant head to represent streams as discharge points for both groundwater flow and VOC transport. Simulating the effects of stream flow explicitly in MIKE 11 was not considered feasible or efficient as this would have required introducing upstream inflows and modeling overland flows south of Woman Creek.

One implication of specifying the stream boundary condition as constant head is that the flow and transport model developed here can not be used to accurately predict the flux of VOCs as baseflow to the stream. This is because it is not possible to distinguish between baseflow and ET loss in near-stream areas. Still, this boundary condition is reasonable for meeting project objectives (i.e., estimating maximum groundwater VOC concentrations in groundwater discharge areas) because stream-bed elevations (used as constant head elevations in the model) are always lower than the up-gradient (uphill) heads.

Constant head boundary conditions were also imposed along the western edge of the saturated zone using available data. This is reasonable to account for the lateral groundwater inflow. The SWWB modeling showed that this influx is small in comparison to the localized vertical recharge and ET loss. In addition, only limited inflow occurs due to the highly divergent saturated flow field in the western IA. Along the eastern boundary, groundwater flows are generally no-flow. Specifying constant head cells was also appropriate here because inflow and outflow is minimal due to no-flow conditions.

4.2.3 Model Performance Criteria

Several types of system response data were used to constrain the integrated model performance. These included the following:

- quarterly monitored well water level data;
- continuously monitored well water level data;

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- groundwater collection system annual average discharge;
- approximate average annual storm discharge;
- approximate average annual sanitary discharge;
- approximate average annual footing discharge:
  - specific buildings;
  - entire IA; and
- average annual surface stream flow at gauging locations.

4.2.4 Model Results

In general, the performance accuracy of the integrated VOC flow model in simulating flow is better than the SWWB model for the same area. This is due in part to the ability to better resolve Site features that affect local hydrologic conditions using a refined grid in the numerical model. Simulated groundwater depths generally are within a meter of observed average annual depths[1]. The performance of the integrated flow model for WY2000 is summarized in comparisons between simulated and observed average annual groundwater levels and discharge information. Figures 4.2 and 4.3 show simulated discharge and groundwater levels performance, respectively.

Simulated drain discharges reasonably reproduce observed discharges. Observed discharge rates are only approximate, but believed to be representative of system flows.

Initially, local-scale single-column unsaturated/saturated zone flow models were developed to more efficiently parameterize unsaturated zone parameters such as, the unsaturated hydraulic conductivity – pressure relation, the moisture retention function, field capacity and wilting point, and ET parameters [including the crop coefficient (Kc), Root Depth Function with time (RDF), Leaf Area Index (LAI) with time, and empirical crop growth functions C1, C2, and C3]. Results from these simulations reproduced observed groundwater fluctuations with time reasonably well, though in some, local grid effects prevent accurate reproduction. In general, though, average annual groundwater levels and key recharge events are represented well with the model.

[1] It should be noted that only wells with complete quarterly measurements were used to compute average annual heads. Heads can vary by 2 to 3 meters seasonally, and without all four quarters, the average head would be biased.

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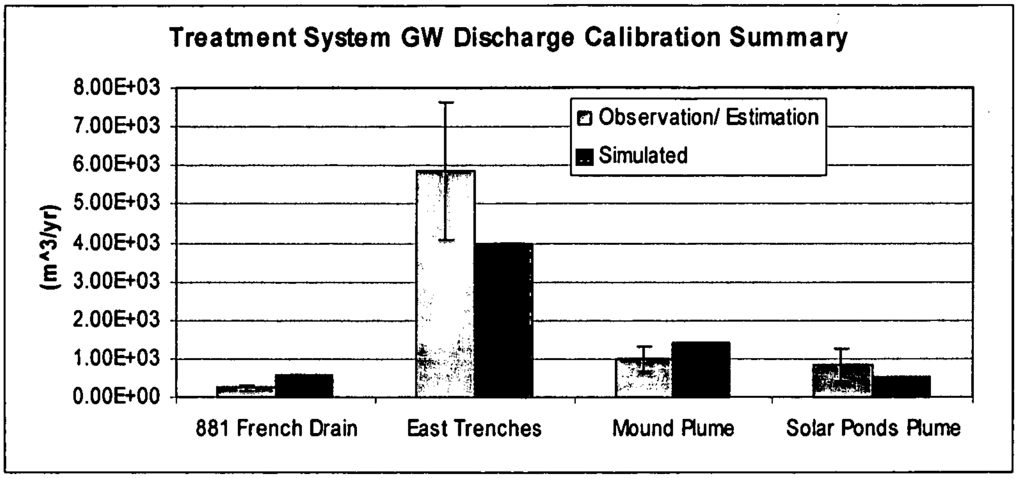

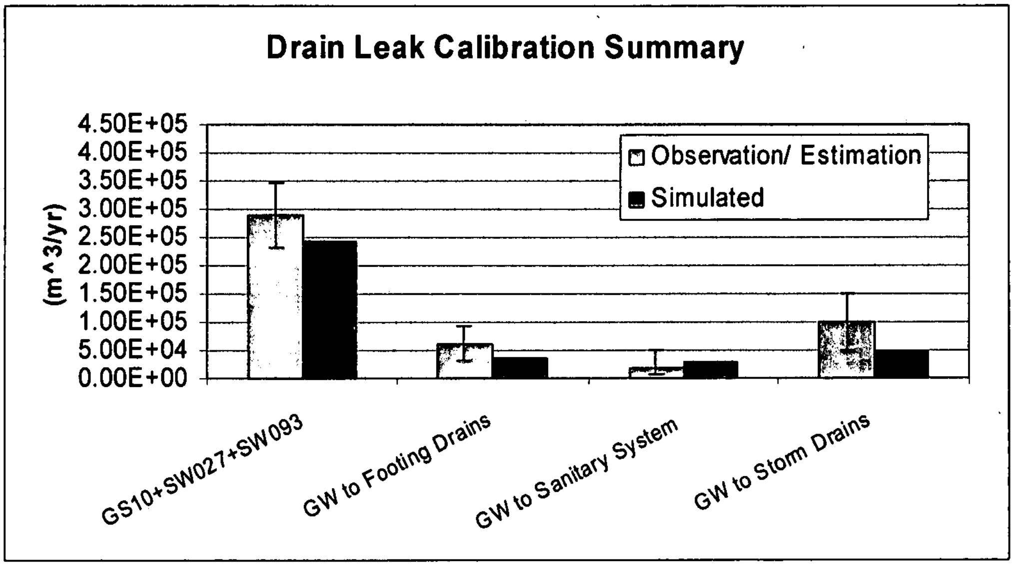

Figure 4.2 Comparison of simulated and observed annual drain and groundwater collection system discharge.

Multiple sub-scale models were developed within the integrated VOC flow model to improve the overall computational performance. This permitted more efficient adjustment of parameter values to improve model performance against observed information. For example, a sub-scale model of the Building 444 area, GS10 drainage, SW027 drainage, SW093 drainage to Walnut Creek, and the 903 Pad area and east were prepared. Modeling showed that all of these areas could be parameterized reasonably well to reproduce observed data, though the 903 Pad area proved more difficult. This is due in part to the added complexity of Arapahoe Sandstone in the area. It is also difficult to simulate due to the deeper and more divergent flow paths in the area, where groundwater is directed either north into South Walnut Creek (B-Pond series), or south into the South Interceptor Ditch (SID), or Woman Creek.

4.3 Integrated Flow Model – Proposed Closure Configuration

This section describes the MIKE SHE integrated modeling of the proposed closure configuration. The purpose of this was to generate a new saturated zone flow field using typical climate (WY2000) and to identify areas where groundwater discharges to surface water.

4.3.1 Approach

Using an approach similar to that implemented in the integrated hydrologic modeling in the SWWB modeling (Kaiser-Hill, 2002), hydrologic effects resulting from the currently proposed closure configuration modification were simulated using the refined integrated flow model. The closure configuration modifications were similar to the SWWB-reported modifications, but differ in several ways. Specific modifications were described in detail in Section 4.3.2 below.

For the CRA, the most important simulated system response from the integrated hydrologic model of the proposed closure configuration was where groundwater discharges to the surface. Discharge rates were also important, but the frequency of groundwater discharge was more important. For example, areas where groundwater discharges to the surface intermittently (i.e., only after large precipitation events) or where it discharges continuously were identified. A typical climate sequence (WY2000) was used to simulated average groundwater levels in the integrated model.

4.3.2 Closure Configuration Modifications

Specific closure configuration modifications are described in this section. Several changes were necessary to the integrated flow model and are summarized below.

The closure configuration land surface topography provided was somewhat different than the previous regrade topography. By comparison, this revised

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surface grading plan reduces the overall amount of fill material, but still included both cut and fill areas within the IA. Two notable borrow areas were located west and north of the Building 371 area. The surface topography of the two borrow areas located north and west of Building 371 actually occurs below the top of weathered bedrock, exposing the bedrock in these areas.

The western end of the SID was removed to accommodate regrade of the entire surface over the Original Landfill area. SMEs indicated that an 18% slope should be used, but currently only a ~11% slope exists. Therefore, only the SID feature was graded over, keeping an approximate 11% slope.

Surface routing based on the new regrade and associated drainage plan also changed in several areas. Areas where surface routing has been modified were shown on Figure 4.4. Four new stream channels were included in the new regrade and drainage plan within the internal part of the IA. These effectively removed surface flow in the former western part of the South Walnut Drainage (upstream of GS10 gage), and the southern unnamed stream that extends into the IA within the North Walnut Creek Drainage (upstream of the SW093 gage). No surface drainage features occur in the southern IA (i.e., former SW022 drainage), the SID, or Woman Creek.

All building footing drains, storm drains, and sanitary drains were removed from the simulation. In the present configuration, these actively remove groundwater throughout the IA where they occur. Leaky water supply lines were removed.

The increased hydraulic conductivity associated with the trenches for all utilities (nine utilities described in Section 4) was not modified. Although some of these may be disrupted (i.e., sanitary lines), given the density and interconnection of these subsurface trenches, it was assumed these disruptions would have only limited impacts (i.e., only very local effects).

The four groundwater collection systems (Solar Ponds Groundwater Collection System, 881 Hillside Groundwater Collection System, the East Trenches Groundwater Collection System, and the Mound Groundwater Collection System) were included for the integrated flow modeling results shown here, but were not included in VOC transport simulations.

Subsurface basement structures associated with four building areas were simulated as low conductivity material. These areas were associated with the Buildings 881, 371, 991, and 771. Much of the basement slabs and walls remained in these areas. The removed portions were determined by the newly regrade surface. All basement material was removed to at least 3 feet below grade. Because of the 60-foot grid resolution, flows calculated within these former building footprints (above the remaining slabs) were not considered in this modeling. Hydrologic effects on flows within and external to building basement flows were evaluated in several individual high-resolution grid models and are described in the Groundwater Interim Measures/Interim Remedial Action Report (IM/IRA) (under development).

Vegetation was assumed to be xeric-type in all former paved, or building areas, while the pre-existing native vegetation remains in all other areas (principally along hillslopes).

Where fill material was placed to adjust to the revised proposed closure configuration topography, it was assumed to be similar hydraulically to the Rocky Flats Alluvium. In all other areas, the pre-existing soils remained.

The WY2000 climate sequence (i.e., the 15-minute precipitation series, the hourly ET series, and the hourly temperature series) was used to constrain the integrated system response for the closure configuration. This climate was assumed to represent a typical year because the total annual precipitation was close to the long-term annual precipitation at the Site (~15 inches/year). Simulating the typical climate sequence was also considered the most appropriate for establishing long-term average groundwater flow paths and groundwater levels to drive long-term transport simulations. A wet-year or dry-year climate was inappropriate because groundwater flows, flow directions, and groundwater levels under these conditions would not be representative of long-term average conditions.

4.3.3 Model Results

Three consecutive years were simulated to stabilize initial conditions. Results from the final year were used to produce average model output. Several types of output were obtained from the model; the average annual groundwater levels were of most interest because they were used as both initial and boundary conditions for the GMS MODFLOW groundwater flow closure configuration simulations (described in Section 6.1.2). Simulated closure configuration groundwater flow directions, the change in groundwater flow directions from current conditions, and average annual ET are also discussed below.

Simulated average and minimum annual groundwater levels were illustrated on Figures 4.5 and 4.6. Results showed that simulated groundwater depths in several areas were above ground surface for average annual conditions (Figure 4.5). These areas occur in the drainage between Buildings 771 and 371 in the north western part of the IA, along the drainage immediately northeast of the Solar Ponds trench (SW091 gage), along the re-engineered South Walnut Creek drainage immediately south of Building 991, and in isolated locations along Woman Creek. These shallow groundwater areas increased in size in the minimum annual groundwater depth plot (Figure 4.6). For the latter case, levels increased only during, or immediately after, large precipitation events (i.e., typical annual spring recharge period).

The simulated change in average annual groundwater levels from current to the closure configuration were illustrated on Figure 4.7. Results showed that water levels changed less than half a meter over much of the central IA, and most of the eastern model area, where proposed closure configuration modifications are minimal. Groundwater levels in the western central IA generally decreased more than 0.5 meters (due mostly top removal of leaky water supply lines). Areas where groundwater increased more than 0.5 meters occurred near all of the buildings with deeper footing drains (i.e., Buildings 771, 371, 881, and 991) and in the central IA where groundwater had discharged to the higher density of storm and sanitary drains (deactivated in the closure scenario).

Changes to the South Walnut Creek drainage and a new routing scheme for the Central Avenue drainage that merges into South Walnut Creek east of the Mound Groundwater Collection System trench caused notable changes in groundwater levels in this area, both increased and decreases.

Simulated closure configuration groundwater flow directions were plotted for both the unconsolidated and upper weathered bedrock layers in the model (i.e., two and three) on Figures 4.8 and 4.9, respectively. Groundwater flow vectors, uniformly sized, show simulated flow directions from the center of each model grid cell. In some areas, flow directions were meaningless because the cell for that layer was desaturated (i.e., the water table was below the bottom of the layer). Results confirm that flows were largely similar between the unconsolidated material and weathered bedrock. They varied in local areas due to local variations in hydraulic conductivities, mostly in the unconsolidated areas associated with utility trenches (more variability in higher density utility areas) or areas where subsurface building structures remain. The flow vectors demonstrate that the simulated closure configuration groundwater in both the unconsolidated and weathered bedrock layers generally flows toward nearby streams.

The change between simulated current and the proposed closure configuration groundwater flow directions for the upper weathered bedrock was shown on Figure 4.10. Results confirmed that flow directions remained largely unchanged, except for some areas. In areas where more significant land reconfiguration occurs, groundwater flow directions differ.

Simulated areas where groundwater discharges to either surface streams, or the ground surface (overland flow that entered streams) were presented on Figure 4.11. This plot showed simulated annual discharge rates to streams, or overland flow. Three of the four modified internal surface streams indicated discharge, while the fourth (Central Avenue) routing that merges with South Walnut Creek east of the Mound Groundwater Collection System does not appear to produce groundwater discharge. As groundwater flow nears streams, an increasing amount was lost via ET as shown on Figure 4.12. Discharge for each cell ranged from approximately 60 m^3/year to nearly 450 m^3/year, with the highest amounts along stream areas. The implication of this was that as groundwater (with VOCs) nears streams, increasing amounts of dissolved phase VOCs in groundwater were lost via ET.

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5.0 FLOW AND TRANSPORT MODEL SELECTION

This section describes the approach used to select the flow and transport code(s) to meet project objectives described in Section 1.0. Three primary steps were involved in selecting an appropriate code: (1) identifying specific modeling needs (model specifications); (2) defining selection criteria; and (3) identifying and selecting the appropriate code. Each of these steps is described briefly in Sections 5.1 to 5.3.

Code selection methodology was derived from the following sources: (1) work done in the SWWB model (Kaiser-Hill, 2002); (2) a Foster Wheeler Environmental Corporation document entitled "RBCA Fate and Transport Models: Compendium and Selection Guidance" prepared for American Society for Testing and Materials (ASTM), dated November 1998; and (3) a DOE report entitled "Computer Code Selection Criteria for Flow and Transport Codes" (Mann et. al., 1999).

5.1 Flow and Transport Modeling Needs

As described in Section 3, the flow system at RFETS within the IA is complex and characteristic of shallow semi-arid hydrologic system. The industrialized nature of the IA also has a notable impact on the surface/subsurface flow system. The conceptual flow/transport models described in Section 4 dictate which key features are necessary components of a flow and transport code so that reliable, long-term VOC fate and transport predictions can be calculated to meet project objectives.

Several features at RFETS impact groundwater flow pathways and velocities and must be considered in a groundwater flow model that supports transport modeling. Some of the more important features include:

- subsurface drain flows (storm, sanitary, building footing drains, and groundwater collection systems);
- preferential flow within utility trenches;
- three-dimensional subsurface basement effects;
- impervious areas; and
- spatial distributions of saturated zone material, unsaturated zone soil properties, vegetation coverage, and topographic details (i.e., changes from current to the proposed closure configuration surface).

Important flow processes that need to be simulated include integrated surface-subsurface flow processes, including: (1) spatial and temporal recharge

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distributions; (2) stream-groundwater interactions; (3) surface ponding; (4) surface discharge at seeps; and (5) ET.

Key transport processes required to simulate transport at RFETS include three-dimensional advection and dispersion, anaerobic and aerobic degradation, sorption, diffusion, volatilization, and plant uptake (or ET).

5.2 Code selection criteria.

	Criterion	Action
1	Ability to simulate processes identified in the conceptual model (transport, decay, and reactive processes)	Reviewed code user manuals
2	Compatibility with existing MIKESHE based water balance model	Reviewed manual
3	Ability to incorporate VOC source terms	Reviewed manual
4	Well documented	Reviewed documentation
5	Code validated	Reviewed documentation
6	Accessibility and support from developers	Discussed with developers
7	Availability of developer for training	Discussed with developers
8	Code demonstrated at field sites, DOE sites	Publications
9	Public domain code	Web site verification
10	Time needed to learn the code	Discussed with users/developers
11	Computational efficiency	Discussed with users/developers
12	Code Cost	Discussed with developers
13	Graphical User Interface	Evaluated Demo, reviewed manual

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5.3 Selection process

Many flow and transport codes are available that are capable of simulating VOC fate and transport at RFETS. As a result, many of these could not be reviewed, or fully evaluated in this study. Instead, only the more appropriate codes were identified and for evaluation against the above criteria outlined in Section 5.1. Based on these criteria, GMS was selected as the best available tool. It had to have the following attributes: (1) utilizes a state-of-the-art graphical user interface (GUI); (2) use is well documented; (3) contains relatively thorough documentation; (4) publicly available; (5) free of cost; and (6) familiarity with the code and its code developers. As such, it met or exceeded selection criteria.

The GMS software developed by the DOD was selected for the transport modeling, primarily because of its well-documented application at DOD, DOE, and Environmental Protection Agency (EPA) sites. The RT3D reactive transport code (Clement, 1997) is a modification of the popular transport code MT3D developed by the USGS (Zheng, 1990). The RT3D code requires a three-dimensional flow velocity array as the basis for transport simulations. This is completed using the MODFLOW 2000 code included in GMS graphical user interface. Unfortunately, the MIKE SHE software does not provide this velocity array in a format that is readily compatible with RT3D. Furthermore, despite recycling the WY2000 climate sequence to obtain a quasi-stable velocity field, the MIKE SHE output still exhibited considerable seasonal flow dynamics which is inefficient for simulating long-term RT3D reactive transport models. As a result, the GMS MODFLOW 2000 code was used as the basis for generating the three-dimensional saturated zone flow field for the RT3D simulation. The conversion of the MIKE SHE model input to the GMS MODFLOW code is discussed in more detail in Section 6.0.

Capabilities of the GMS software include the following:

- Advanced graphical interface. This feature allows the modeler to incorporate all flow and transport information into a single graphical interface. It also provide a powerful interface for both input and output of a substantial amount of modeling data that greatly improves the overall analysis of computational simulations. The interface greatly aids in graphical, or direct spreadsheet specification of model input and grid generation. In addition, more advanced features allow model output from both the MODFLOW flow and RT3D transport models to be displayed readily, or in an animated mode, for presentations;

- The GMS software incorporates the USGS MODPATH particle tracking code, which is also a key feature employed in this study to evaluate groundwater flow velocities and pathways (i.e., VOC source location assessment); and

- The GMS software also meets the selection criteria.

6.0 GROUNDWATER FLOW AND TRANSPORT - HISTORICAL AND CLOSURE CONFIGURATION

The development of steady-state groundwater flow and reactive transport models used to simulate the historical growth of the currently observed PSAs and their subsequent fate under proposed closure configuration conditions are described in this section. The overall modeling approach is described first in Section 6.1. The development of groundwater flow and transport models, application, and results are described in Section 6.2.

6.1 Modeling Approach

The overall modeling approach, described first in Section 6.1, is more detailed than the project approach described earlier in Section 3.1. The approach used to convert integrated flow model input into equivalent MODFLOW steady-state flow model input is described first, in Section 6.1.1. The approach used in developing steady-state MODFLOW models and groundwater flow path analysis, using the particle tracking code, MODPATH, are described next in Section 6.1.2. The approach used to model reactive transport of historical PSA growth from inferred VOC sources, determined through flow path analysis, is described in Section 6.1.3. Finally, the approach used to simulate the eventual fate and transport of present PSA concentration distributions, from inferred VOC sources, under the closure configuration is described in Section 6.1.4.

Results of the groundwater flow and transport modeling are described in Section 6.2. PSA-specific areas are described first in Section 6.2.1. Section 6.2.2. summarizes general findings from the modeling for all PSAs.

6.1.1 MIKE SHE Conversion to MODFLOW

Model input from the integrated MIKE SHE flow model was converted into equivalent GMS MODFLOW flow models. Although some MIKE SHE model input arrays converted directly, others had to be approximated. Specific model input that could be converted directly included the following:

- the topographic surface;
- model layer surface elevations;
- model layer hydraulic conductivities;
- locations and invert depths of river, drains, and constant head boundary cells; and
- locations and recharge rates (leakage) of water supply lines.

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Other input did not convert directly and required additional adjustment in the GMS MODFLOW model. These included the following:

- river conductance;
- drain conductance;
- recharge; and
- ET parameters.

Horizontal and vertical hydraulic conductivity arrays from the integrated flow model had to be slightly adjusted during MODFLOW flow model simulations to reproduce the distribution of time-averaged well VOC concentrations. The integrated flow modeling did not incorporate transport information to help constrain the hydraulic conductivity values. As a result, slight adjustments to the hydraulic conductivity values in the MODFLOW models were appropriate to improve groundwater velocities so that particle tracking distances were consistent with PSA extents. No adjustments were made to the integrated flow model hydraulic conductivity values. For consistency, the modified hydraulic conductivity values in MODFLOW were used for simulating later closure configuration scenario simulations (Section 6.2).

River and drain conductance values also had to be adjusted so that observed groundwater discharges to streams and drains within each PSA were reproduced. The locations of drain and river cells coincided with those specified in the integrated flow model.

Several recharge zones were defined within each PSA flow model based on unsaturated soil and vegetation zones defined in the integrated flow model. Zonal recharge values within each GMS flow model were also adjusted to reproduce observed information (groundwater levels and discharge) and to produce particle flow paths consistent with assumed PSA extents. The total simulated MIKE SHE model annual recharge to the saturated zone (within a given GMS model area) was used as a general constraint on the overall simulated steady-state GMS MODFLOW water budget.

ET in the MIKE SHE model was simulated for both the unsaturated and saturated zones. In MODFLOW, it is simulated as a net loss from the saturated zone. The total simulated MIKE SHE model annual ET loss from the saturated zone within each PSA flow model area was also used as a general constraint on the overall simulated steady-state GMS MODFLOW water budget.

6.1.2 Groundwater Flow Model Development

Eight different steady-state PSA MODFLOW groundwater flow models were developed to improve computational efficiency, rather than attempt to simultaneously simulate the flow and transport of all PSAs in a single flow model.

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These PSA model areas were also used as the basis for historical and proposed closure-condition reactive transport modeling. The rationale for selecting these boundaries is described further in Section 6.3. The eight model areas are defined as the following:

- PSA 2N (Northern extent of 903 Pad area and East Trenches area);
- PSA 2S (Southern extent of 903 Pad area and Ryan's Pit area);
- PSA 5 (Mound /Oil Burn areas);
- PSA 9 (881 Hillside area);
- PSA 10 (Building 444 area);
- PSA 12 (Central IA);
- PSA 14 (Building 771/IHSS118.1 area); and
- PSA 15 (Western Former Solar Ponds area).

6.1.2.1 Model Boundaries and Boundary Conditions

Spatial extents of each PSA groundwater flow model domain are shown on Figure 6.1. They are defined based on several factors. The extent of each model included the historical, current, and proposed closure configuration VOC distribution. It was large enough that external boundary conditions (i.e., along the edges) did not affect internal flow and transport calculations except at areas where groundwater discharges to the surface. The MODPATH code was used to confirm that model boundaries were appropriate by producing long-term particle tracks from suspected source areas that could then be evaluated using observed Site data.

In some instances, PSA model boundaries overlap as shown on Figure 6.1. These overlaps only reflect the need to have conservatively large model areas to avoid external boundary condition effects on internal calculation cells. Several PSA models (i.e., PSA 2N, PSA 2S, and PSA 12) included more than one PSA and multiple sources.

Site hydrogeologic features were used to develop initial model boundaries. For example, because source areas occur in uphill or mesa areas, they currently flow, or will eventually flow, down-gradient towards streams. As such, downhill boundaries were assigned at stream boundaries which is appropriate because they coincide with groundwater divides and represent groundwater discharge areas. In some cases, appropriate internal drainage boundaries were specified at stream locations, instead of constant head cells (i.e., PSA 12). Uphill boundary conditions were generally prescribed as constant heads, but in some instances, were specified as no-flow conditions (where groundwater flow directions parallel the boundary). Hydraulic heads derived from the integrated MIKE SHE flow model were used for these constant head boundary cells. Simulated average annual heads, obtained from the integrated model, were also used as initial heads for the steady-state PSA flow models.

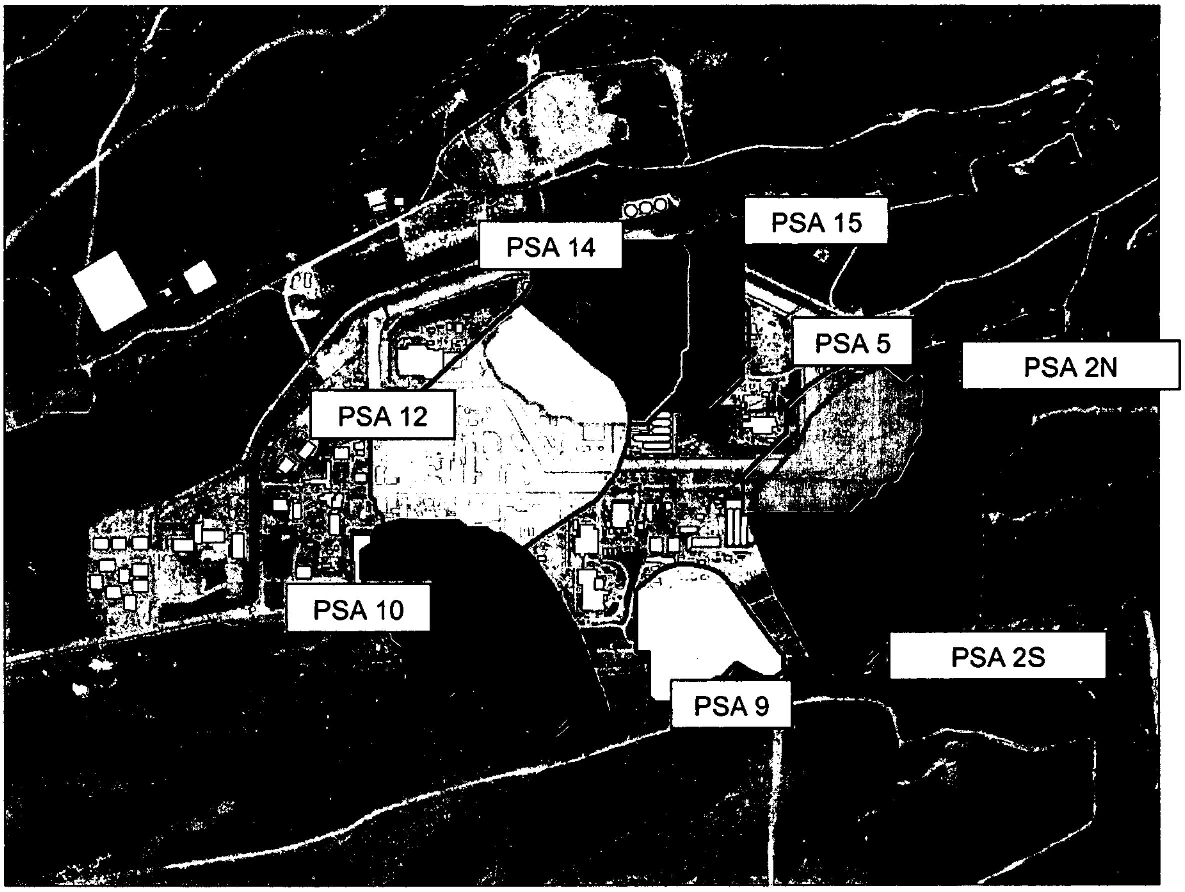

Figure 6.1. PSA locations.

Other spatial model boundary conditions assigned in each PSA flow model included river cells, leaky water supply lines (simulated using the MODFLOW well package), drain cells, spatially distributed recharge, and ET. Although locations of these boundary conditions coincided with the integrated model, some parameter values had to be determined through iterative model simulations (constrained by performance criteria).

Although the steady-state flow models could not reproduce the transient behavior simulated in the integrated MIKE SHE flow model, the simulated steady-state flow fields are appropriate for simulating long-term flow and transport. For example, transient system flow response, such as annual or seasonal recharge and ET variations, affect groundwater levels, but they generally do not significantly perturb steady-state groundwater flow paths or velocities within the

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IA. These flow paths and velocities are strongly controlled by the underlying hillslope morphology.

The GMS flow models were constructed using input from the integrated MIKE SHE flow model. Though much of the model input converted directly, some required modification.

6.1.2.2 Parameter Estimation

Parameterization of the flow model recharge rates was accomplished using the automated parameter estimation code, PEST (Watermark, 2003), included within the GMS software graphical user interface (GUI). Other parameter values (such as drain and river conductance) were adjusted manually, given their spatial complexity. Spatially distributed recharge values (within zones) were adjusted based on the performance criteria described in Section 6.1.2.3. Recharge was varied over six to eight different zones within each model. More permeable areas were assigned initial recharge values, while recharge in impermeable areas (i.e., building, or paved areas) was kept constant at zero. High and low recharge rates were specified for each recharge zone value to limit the possible values considered in the PEST simulations. These high and low values were determined based on ranges determined from the MIKE SHE flow model.

Hydraulic conductivity values for the unconsolidated material layers and weathered bedrock layers were manually adjusted in each MODFLOW flow model to improve the correlation between particle paths and concentration distribution, and between observed and simulated heads. Though the flow model had zoned conductivity distributions, only the conductivity of entire layers was varied by a multiplication factor that ranged from 0.5 to 5.0. The original distribution was preserved. Multiplication factors were limited in magnitude to retain consistency with the MIKE SHE model.

Simulated average annual groundwater flow conditions from the integrated flow model and observed average annual well water level information (quarterly water levels, WY2000) were used as model performance criteria. Simulated average annual groundwater discharges from the integrated flow model, combined with observed drain and building discharge, were also used to constrain the MODFLOW flow model parameter values.

6.1.2.3 Model Performance Criteria

Several types of criteria were used to constrain the performance of individual MODFLOW models. These included the following:

- integrated flow model results:
    - simulated mass balance for individual PSAs (i.e., net recharge, ET, stream baseflow, and collective PSA drain flows), and

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- simulated average annual heads;
- average annual water levels (at wells);
- observed discharges from key buildings, or groundwater collection trenches (i.e., East Trenches Groundwater Collection System, Mound Groundwater Collection System, 881 hillside system, and Solar Pond Area Groundwater Collection System); and
- groundwater flow paths and velocities as inferred based on assumed source locations, release times, and PSA extents.

Simulated average annual heads and discharges from the integrated flow model were used to constrain the steady-state MODFLOW models for each PSA. Although the integrated flow model reproduced groundwater levels well (i.e., generally less than one meter residuals), in some instances they did not. As a result, average annual groundwater levels were also used to help constrain each MODFLOW flow model input parameter values.

Observed discharges were only available for certain building footing drains and subsurface drains (i.e., storm and sanitary). This information was used to the extent possible, given that individual PSA flow model boundaries cut across some drains. Cumulative approximate observed discharges (Kaiser-Hill, 2002) could not be used as criteria in the individual flow models. However, simulated annual integrated flow model groundwater discharge for individual drains (storm, sanitary, and groundwater collection trenches) was calculated and used to constrain the MODFLOW flow model parameter values. Other simulated annual discharges were used to constrain values included net recharge, net ET, net baseflow, and stream inflow over each model area.

Results of the MODPATH particle tracking analysis were also used as performance criteria to constrain input parameter values. Particles were introduced at inferred VOC source locations and allowed to travel between 30 to 50 years based on HRR information (Appendix A) and discussions with SMEs. Groundwater flow parameter values (such as saturated hydraulic conductivity, recharge rates, and ET rates) were adjusted so that particles traveled to PSA downstream extents and within lateral boundaries (as defined on Figures B-1 through B-7). Only parent VOC PSA distributions were considered in this analysis. Saturated hydraulic conductivities were only varied slightly from those obtained in the integrated flow model. This was appropriate as the information from transport was not included in development of the integrated flow model.

6.1.2.4 Flow Path Analysis – Particle Tracking

Once the individual GMS groundwater flow models were developed, the USGS particle tracking code, MODPATH, was iteratively used to assess the number, location, and introduction times of individual assumed VOC sources with each PSA. Particle tracking was used to confirm that transport from inferred VOC source areas produced reasonable pathways and velocities within PSA

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boundaries (Figures B-1 through B-7, Appendix B). If particles migrated considerably further than the PSA boundaries, it was assumed that the porosity was too low, conductivity values were too high, or sources were introduced too early. Conversely, if particles only migrated short distances from assumed source areas, it was concluded that sources were not introduced early enough, porosity was too high, conductivity values were too low, or that sources were placed in the inappropriate hydrostratigraphic layers. Finally, if assumed source locations, depths, or numbers of sources resulted in poor VOC travel times or pathways, iterative analysis using particle tracking was used to assess additional scenarios.

6.1.3 Transport Modeling Approach – Historical Conditions

The uncertainty associated with groundwater sources precluded using a traditional approach to modeling the fate and transport of VOCs. Instead a sensitivity analysis was conducted that involved several steps. First, parameters that most affected the fate and transport of VOCs in groundwater were identified. Next, an approximate range of parameter values was estimated that effectively bracketed the spatial distribution of time-averaged concentrations within each PSA. Finally, effective source concentrations were estimated at assumed source locations.

Individual reactive transport models were developed for each PSA using the three-dimensional steady-state groundwater flow fields simulated for each of the PSA MODFLOW models. The RT3D code was used to develop the reactive transport models. Based on comparisons between the draft surface water PRGs and maximum observed sample concentrations, only the PCE, TCE, and CCl_4 parent VOCs were selected for transport modeling. Associated VOC daughter products were calculated internally by the reactive transport models.

The locations, depths, and release times of VOC sources, approximated through steady-state particle tracking analysis, were used in the reactive transport simulations. Although particle-tracking results reflected the advective transport of VOCs from assumed source areas, they did not consider the combined effects of degradation, sorption, dispersion, or diffusion on plume migration. As a result, the reactive transport modeling was used to confirm the MODPATH source locations, depths, and release times of VOC sources. Because source concentrations were unknown, effective values were iteratively determined through the reactive transport modeling.

The relative sensitivity of VOC transport to key model parameter values was evaluated iteratively in fourteen sensitivity runs summarized in Table 6.1. Key parameter values were adjusted in the reactive transport models for each PSA to reproduce the spatial distribution of time-averaged concentration data. Although limited Site-specific information was available for these parameter values (i.e., source location, chemical sorption, hydraulic conductivity, porosity, degradation rates, and source concentrations), sensitivity simulations were used to bracket

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the range of values compared to published information. Results of sensitivity simulations indicated that ranges could be constrained.

During the sensitivity evaluation, reproducing time-averaged concentrations in wells down-gradient of the source was emphasized. Near-source concentrations probably do not reflect well-mixed groundwater concentrations (either too high, or too low). Successive model iterations were made until model results reasonably simulated observed average historical well concentrations.

6.1.3.1 Transport Model Parameters

The approach used in specifying key transport model parameters adjusted in the sensitivity simulations (summarized in Table 6.1) are described in this section. Information on inferred VOC sources, including locations, depths, timing, effective concentrations, and composition are described in Section 6.1.3.1.1. Rationale for specification of degradation, sorption and dispersion parameter values in the reactive transport modeling of the historical and the closure configuration is described in Sections 6.1.3.1.2 through 6.1.3.1.4, respectively.

6.1.3.1.1 Inferred VOC Sources

VOC source information represented the greatest uncertainty in transport modeling at the Site. Input parameters specified in the reactive transport model simulations for source information included source cell locations, source depth (unconsolidated material, or bedrock), source introduction timing, effective source concentration, and source VOC composition. HRR information, described in Appendix A, was used as the primary source of information for specifying this source information. This database was developed from the HRR, with additional input from Site SME, Nick Demos.

In most PSAs, information on likely VOC sources was limited (see Section 3.3.3). For example:

- the location of a possible source was not known with confidence to within several grid cells (60-foot by 60-foot model grid);
- the depth of source release was not recorded;
- the year the source was introduced at the Site was often based on the first time the spill was noted (non-conservative assumptions), or conversely, the date that the building or feature where the source was located was built (conservative assumption). It was often unclear how the source release date was determined;
- the concentration of the source was rarely noted, and when noted it was often estimated; and
- the source composition was often vague (i.e. "oil-grease" or "solvents") or not well documented.

Table 6.1. Sensitivity simulation summary.

Sensitivity Simulation	Rationale
Base case	This model simulation represented a base case. Parameters in subsequent models were varied from this model.
Source Depth	The contaminants move more slowly in the lower weathered bedrock layers because of the lower hydraulic conductivity.
Split source release between two layers	Produces significant difference in down-gradient concentrations. Depends on differences between permeabilities in unconsolidated material and weathered bedrock.
Low dispersivity	Produces conservatively high concentrations downgradient. Reduces lateral and vertical concentrations.
High dispersivity	Produces comparatively lower down-gradient concentrations. Simulated concentrations located off the primary flow path (lateral and vertical) were higher.
Low sorption	Produces higher down-gradient concentrations. Less time for degradation. Increased likelihood of higher concentrations reaching discharge locations. Larger area with higher overall concentrations for a constant source.
Low porosity	Produces lower down-gradient concentrations. Less time for degradation. Increased likelihood of higher concentrations reaching discharge locations. Larger area of high overall concentrations for a constant source.
High porosity	Produces lower down-gradient concentrations. Contaminants travel slower over a given time period. More time for degradation to attenuate transport.
Low source concentrations	Produces lower down-gradient parent product concentrations. Lower concentration of parent (source) also gives lower concentration of daughter compounds.
High source concentrations	Produces higher down-gradient parent product concentrations. Higher concentration of parent (source) also causes higher concentration of daughter compounds.
Low degradation rates	Produces higher parent product concentrations down-gradient. Daughter product concentrations are lower down-gradient. Can be less conservative with respect to daughter products. Differs by PSA and VOC.
High degradation rates	Produces lower down-gradient parent concentrations, but can increase daughter product concentrations. Depends on factors that control groundwater velocity and relative parent/daughter compound degradation rates. Differs by PSA and VOC.
Low hydraulic conductivity (MODFLOW model)	Produces lower down-gradient parent concentrations. Groundwater and contaminants travel slower and allow more time for degradation.
High hydraulic conductivity (MODFLOW model)	Produces higher down-gradient parent concentrations. Groundwater and contaminants travel faster allowing less time for degradation.

*Note: The term "conservative" in Table 6.1 represents the case where VOC concentrations are simulated high.

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6.1.3.1.1.1 Location

Inferred source locations were determined initially based on their proximity to observed high concentrations in groundwater and using the HRR information (Appendix A). Priority 1 releases were considered as sources first because their source volumes were assumed to be the greatest. Priority 2 releases were considered next, and Priority 3 releases were not considered significant enough to model in this study. In the transport models, inferred VOC sources were generally specified within a single grid cell (60-foot by 60-foot) at constant concentrations. However, in several instances where the VOC source was inferred over an area larger than a single cell, multiple cells were used to specify the source. Source locations specified in the database were modified only in cases where the position was not specifically known. For example, a potential source associated with VOC activities in a large building was located in the center of the building in the database. In the RT3D model this location might be moved to a loading dock as assumed spill location in this area.

A spatial plot of inferred VOC source locations based on model results is shown on Figure 6.2 (PCE and TCE) and Figure 6.3 (CCl_4). A summary of inferred VOC sources determined through modeling and from HRR information is included in Appendix B. The model-specified source cells and initial modeled concentrations are summarized in Appendix C.

6.1.3.1.1.2 Depth

Information on the depth of inferred VOC sources was largely unavailable. However, VOC sources were conceptualized (Section 3.5) as resulting from DNAPL releases at the surface or in the unsaturated zone that migrated downward and pooled above lower permeability material (assumed here to be the weathered bedrock). As a result, simulated VOC sources were specified either within the unconsolidated material, within the weathered bedrock, or both. If the MODFLOW model results indicated that the water table was below the weathered bedrock surface, the source was placed in the upper weathered bedrock model layer. If this layer was also unsaturated, the source was placed in the lower weathered bedrock layer. Source depth played a significant role in defining transport rates considering the contrast in conductivity between the unconsolidated material and weathered bedrock.

6.1.3.1.1.3 Timing

Inferred VOC sources were assumed to start based on HRR information and discussions with Site SMEs, if available. It was assumed that source start dates preceded the actual release times noted in the HRR. If this information was unavailable, inferred VOC sources were assumed to have been introduced into the groundwater system sometime between 1950 and 1970. These assumptions were evaluated through particle tracking analysis and reactive transport simulations using time-averaged concentration data.

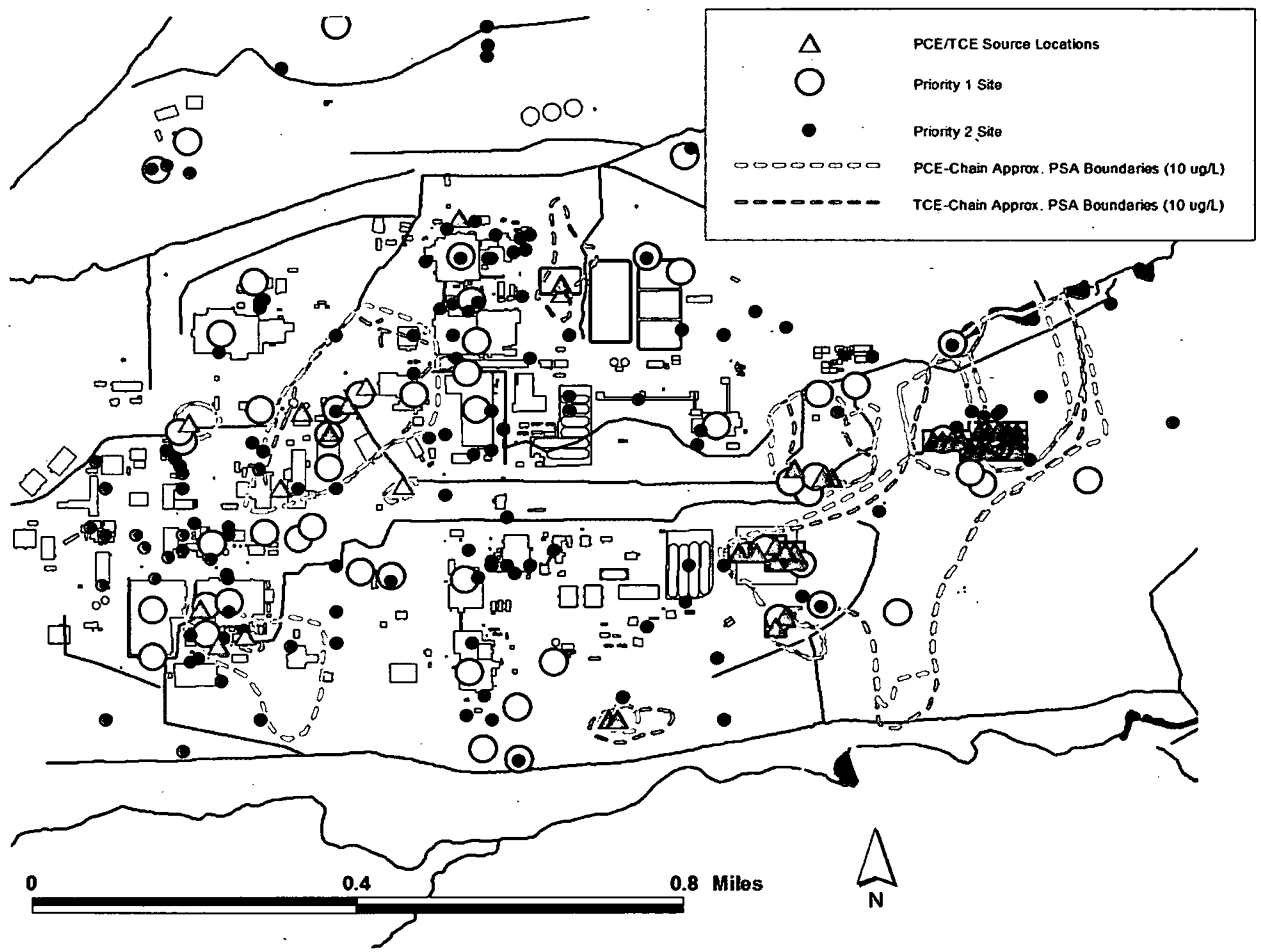

Figure 6.2. Priority 1 and 2 HRR releases with inferred PCE/TCE source locations.

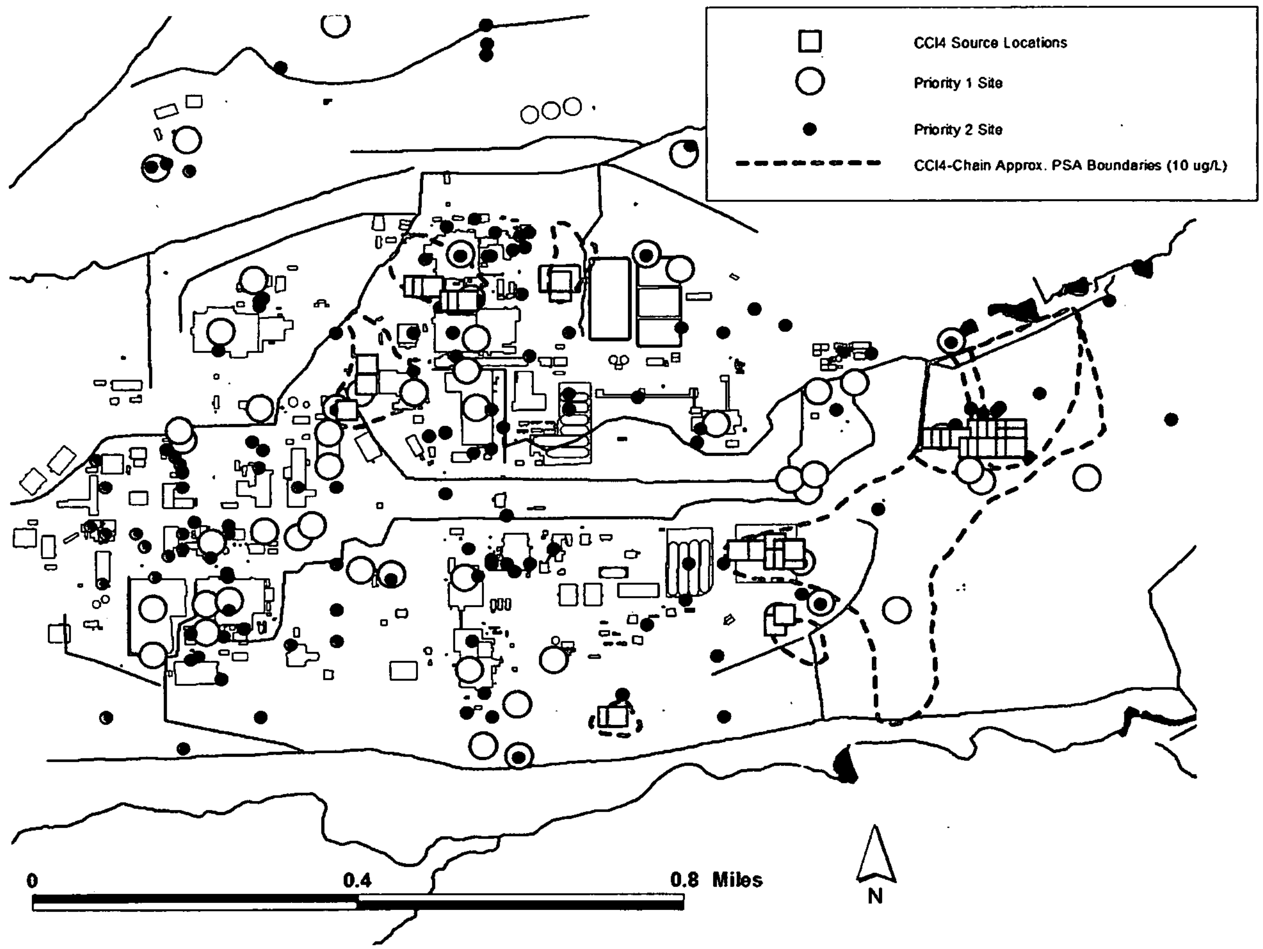

Figure 6.3. Priority 1 and 2 HRR releases with inferred CCl_4 source locations.

6.1.3.1.1.4 Concentration

Information on groundwater concentrations for inferred VOC sources was unavailable from either the HRR, or sample locations. As a result, a range of effective concentrations at inferred VOC source locations was determined by reproducing time-averaged concentrations using the reactive transport model. This was an iterative process in which effective source concentrations at inferred VOC source locations were first assumed, and then subsequently modified to reproduce the time-averaged groundwater VOC concentrations. Effective VOC source concentrations were kept constant through both historical and closure configuration scenarios given that most well concentrations with time are relatively constant (as discussed above in Section 2.3.4).

Although near-source well concentrations suggested where sources might be inferred, their time-averaged concentrations could not be used to determine effective source concentrations. Part of the reason for this was that near-source concentration information does not adequately represent average, well-mixed, concentrations within either the unconsolidated material or weathered bedrock. In other words, local heterogeneity, well-screening, or DNAPL architecture near inferred VOC sources can cause concentrations in nearby wells to be either higher, or lower, than the actual concentration perpendicular to the plume pathway. As a result, effective source concentrations could be either higher, or lower, than time-averaged concentrations at wells near inferred VOC sources.

6.1.3.1.1.5 Composition

In most instances, the HRR did not provide information on the specific VOCs released into the environment. Instead, the occurrence and relative concentrations of VOCs at samples near inferred VOC sources were used, to the extent possible, to determine likely individual source VOCs (see Figures B-1 to B-7 in Appendix B). In most PSAs, however, individual source VOCs had to be assumed. As a result, particle tracking analysis and transport modeling using historical concentration information were both used to iteratively confirm initial assumptions about source VOCs.

The first step in the assessment of source composition was to identify which of the two degradation chains were observed in the PSA. Often both the PCE and CCl_4 chains were present. Next, parent compounds (PCE and/or CCl_4) were introduced and simulated over a range of degradation rates. Where this approach could not reproduce observed time-averaged PCE sample concentrations, TCE was systematically co-introduced as a source. Some areas had much higher historical TCE (daughter) concentrations than that of PCE (a possible parent VOC) and it was reasonable to introduce TCE as well as PCE at the source to explain the observed concentration data. In addition, TCE use on the Site was documented. No CCl_4 degradation product sources had to be specified a model to reproduce observed concentrations.

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6.1.3.1.2 Degradation Rates

The range of degradation rates initially used in the transport simulations was based on published values from Aronson and Howard (1997) (Table 6.2). Subsequent reactive transport sensitivity simulations reduced the range of possible degradation rates compared to the published ranges (compiled from many different environments). Degradation rates were specified as constant within individual PSA models, but differed from model to model. This was consistent with a Site biodegradation study (Kaiser-Hill, 2003b) that concluded degradation rates likely vary across the Site depending on spatially varying factors such as redox parameters, dissolved oxygen (DO), and observed groundwater contamination. Available data was inadequate to justify varying degradation rates within individual PSA models.

Table 6.2. Published range of degradation rates.

VOC	Range of Degradation Rates Min – Max, Mean (day^{-1})	Reference(s)
PCE → TCE	0 – 0.41, 0.027	Aronson and Howard, 1997
TCE → DCE	0 – 0.19, 0.011	Aronson and Howard, 1997
DCE → VC	NA	NA
VC → Ethene	0 – 0.12, 0.018	Aronson and Howard, 1997
CCl_4 → Chloroform ($CHCl_3$)	0 – 1.73, 0.34	Aronson and Howard, 1997
$CHCl_3$ → Methylene Chloride (CH_2Cl_2)	0.004 – 0.24, 0.08	Aronson and Howard, 1997
CH_2Cl_2 → Methyl Chloride (CH_3Cl)	NA	NA
CH_3Cl → Methane (CH_4)	NA	NA

6.1.3.1.3 Sorption

A range of sorption (K_d) values was calculated for each VOC based on published (EG&G, 1994) ranges of Site-specific soil parameters (organic matter content [f_{oc}] and clay content) and VOC partitioning constants. A linear sorption isotherm was assumed.

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The following equation was applied to calculate the sorption K_d values:

$$K_d = K_{om} + K_{min} = (f_{oc} \times K_{oc}) + K_{min}$$

Where:

K_{min} = Partitioning coefficient for VOC between water and mineral surfaces
K_{oc} = Partitioning coefficient for VOC between water and organic matter
f_{oc} = Organic fraction

Initial transport simulations used the calculated range, summarized in Table 6.3, were later refined on a PSA-by-PSA basis with the transport simulation results.

Table 6.3. Range of sorption constants.

VOC	Minimum K_d (L/mg)* F_{oc} = 0.0004; K_{min} = 0	Maximum K_d (L/mg) F_{oc} = 0.0022; K_{min} based on 80% smectite fraction of total clays
PCE	1.5×10^{-7}	3.8×10^{-6}
TCE	5.0×10^{-8}	3.0×10^{-6}
cis-1,2-DCE	2.6×10^{-8}	2.3×10^{-6}
VC	$8.0 \times 10^{-**}$	$1.7 \times 10^{-6**}$
CCl_4	1.8×10^{-7}	4.0×10^{-6}
CCl_3	1.9×10^{-8}	2.5×10^{-6}
CCl_2	$2.8 \times 10^{-9**}$	$1.7 \times 10^{-6**}$
Methyl chloride (CH_3CCl)	$1.6 \times 10^{-9**}$	$1.0 \times 10^{-6**}$

*Based on OU1 report (EG&G, 1994), minimum f_{oc} range and K_{oc} values also reported in the OU2 report. These K_{oc} value compared well with values compiled by Schwarzenbach,Gschwend, and Imboden (1993).

**K_{min} and K_{oc} values were not reported in the OU1 report (EG&G, 1994). K_{oc} values were assessed by relative comparisons of the octanol-water partitioning coefficients for these VOCs to determine an approximate K_{oc}. K_{min} values were similarly approximated for these VOCs based on K_{min} value trends for the rest of the degradation chain,

6.1.3.1.4 Dispersion

Longitudinal dispersivity was specified in the reactive models based on approximate PSA extents. The transport model calculated a spatially varying dispersion coefficient based on the dispersivity and the velocity from the flow simulation (dispersivity multiplied by average linear velocity). Vertical and cross-flow components were entered as fractions of the longitudinal value. The range of dispersivity values applied to initial simulations was taken from Gelhar et al. (1985), which presents an empirical correlation between plume length and longitudinal dispersion. Observed PSA travel distances at the Site range from 50 to about 500 meters. Based on this, the correlation presented in Gelhar et al. (1985) suggests that the longitudinal dispersivity should be between one and 100 meters. This range was further refined for the Site to between 5 and 30 meters through preliminary reactive transport simulations.

The vertical and cross-flow components were specified as 1/100th and 1/10th of the longitudinal dispersivity, respectively. These values were based on the published values in Fetter (1998) and in an RT3D manual (Clement, 2003).

6.1.4 Transport Modeling Approach – Closure Configuration

For each PSA model, steady, long-term concentrations were estimated at groundwater discharge locations down-gradient of inferred VOC source areas identified through historical transport modeling. Because of the uncertainty in model input parameters that affect the fate and transport of VOCs in groundwater at RFETS, multiple simulations were run to generate a range of possible long-term, steady concentrations at possible groundwater discharge locations. To accomplish this, key flow and transport model parameter values affecting the long-term simulated groundwater discharge location concentrations were varied based on ranges determined in the sensitivity analysis of historical transport modeling (as described in Section 6.1.3).

For the closure configuration simulations, sixteen simulations[2] were run to estimate the range of groundwater discharge location concentrations. Simulations were conducted for both CCl_4 and/or PCE/TCE-chain, depending on whether maximum observed concentrations were higher than draft surface water PRG values.

6.2 Flow and Transport Model Results

Flow and transport modeling results are summarized in this section. PSA-specific modeling results are described first in Section 6.2.1, while more general findings are discussed in Section 6.2.2. The discussion of PSA-specific modeling results presented in Section 6.2.1 is separated into five different areas. For each PSA model area, the following results are discussed in detail:

- Groundwater flow model results;
- Simulated groundwater VOC sources;
- Particle tracking results – historical conditions;
- Transport model results – historical conditions; and

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[2] Two additional simulations (to those listed in Section 6.1.3) that varied several model parameters were run to observe model response.

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- Transport model results – the closure configuration.

6.2.1 PSA-Specific Modeling Results

6.2.1.1 PSA 2N – 903 Pad /East Trenches Areas

The PSA 2N model area, located in the east-northeast part of the Site, is defined on Figure 6.1. The complexity of the area and results from initial transport modeling led to the development of a focused subset model (PSA 6 and 7) that concentrated on the East Trenches source area. The PSA 6 and 7 model outline is shown on Figure 6.4. The initial results for the larger PSA 2N model area are presented in this section for completeness and to explain the rationale for creating a subset model.

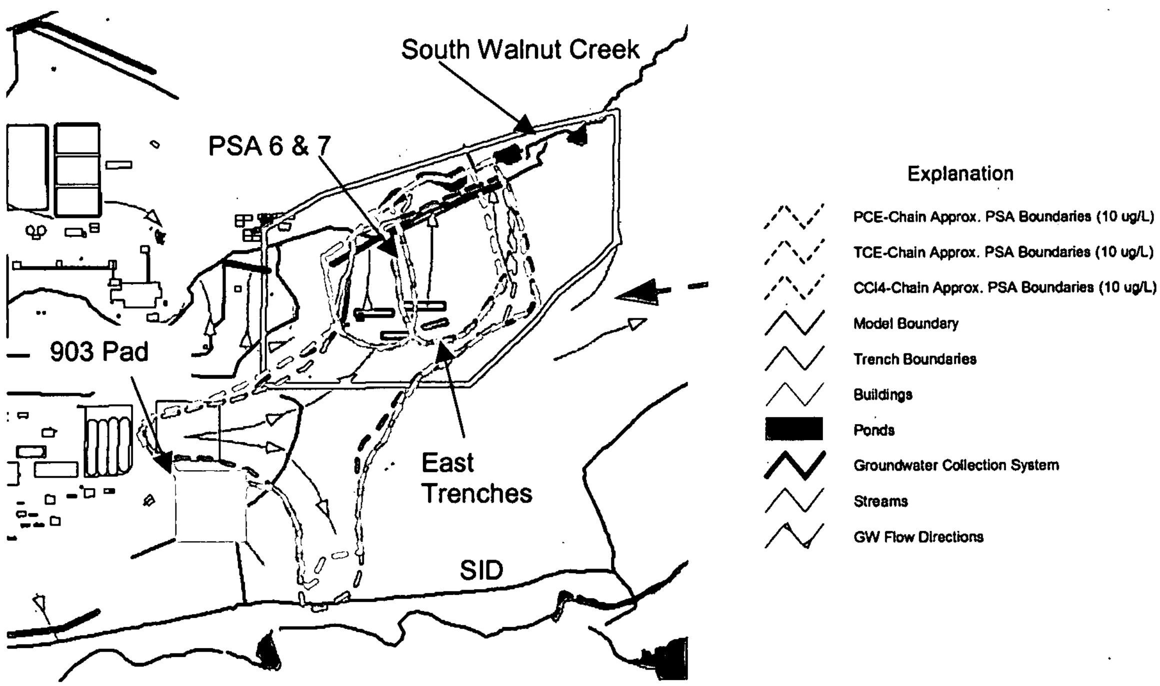

Figure 6.4. PSA 2N - Model area and PSA 2S, PSA 6 and PSA 7.

6.2.1.1.1 Groundwater Flow Model Results

A ground-water divide extends from the 903 Pad to the east-northeast in PSA 2N. Groundwater flows along the divide and then diverges either north to South Walnut Creek (B-Pond Series) or south to the SID and Woman Creek. Because flow conditions in this area are complex, the PSA 2 area was divided into northern and southern models (PSA 2N and PSA 2S) to better simulate the northward and southward components of flow from the divide.

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The water balance calculated by the PSA 2N flow model indicated that water entered the model though constant head boundaries and recharge and left the model by constant head boundaries and ET. Simulated groundwater levels reproduced average annual groundwater levels within 1 to 2 meters (Figure 6.5).

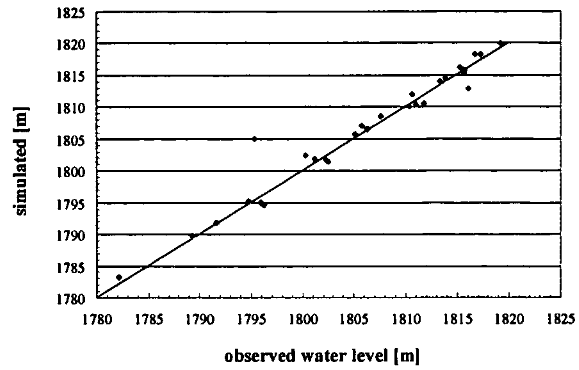

Figure 6.5. PSA 2N - Simulated versus average observed annual groundwater levels (meters above msl).

6.2.1.1.2 Simulated Groundwater VOC Sources

HRR information suggested probable VOC sources for the PSA 2 (PSA 2N and PSA 2S) area were the 903 Pad area and East Trenches shown on Figure 6.4. Detectable VOC concentrations in down-gradient wells and the B-ponds were attributed primarily to the T-3 and T-4 trenches and possibly the 903 Pad area source (Kaiser-Hill, 1999). Sources were also considered in the T-1 and T-2 trenches.

The two primary inferred VOC source locations in this area (both Priority 1 releases) are the East Trenches (T-1 to T-4) and the 903 Pad. The East Trench sources are documented in the HHR database (Appendix A, reference numbers 277, 279, 280, and 287). The 903 Pad source is documented in the HHR database (Appendix A, reference numbers 34, 39, 178, and 179).

6.2.1.1.3 Particle Tracking Results – Historical Conditions

Particles introduced in the 903 Pad and East Trenches (T-1 through T-4) areas were allowed to travel for 42 years based on the HRR information. Results of the particle tracking, summarized on Figure 6.6, show that simulated flow paths from inferred sources were consistent with the PSA 2N boundary. Particles introduced at the East Trenches (PSA 6 and 7) traveled north and intercepted South Walnut Creek and the B-ponds within the assumed release time. In the southern PSA 2N area, particles traveled from the 903 Pad source to the east and then north past the East Trenches source and commingled with the inferred VOC source particles introduced at the East Trenches. Particles from the 903

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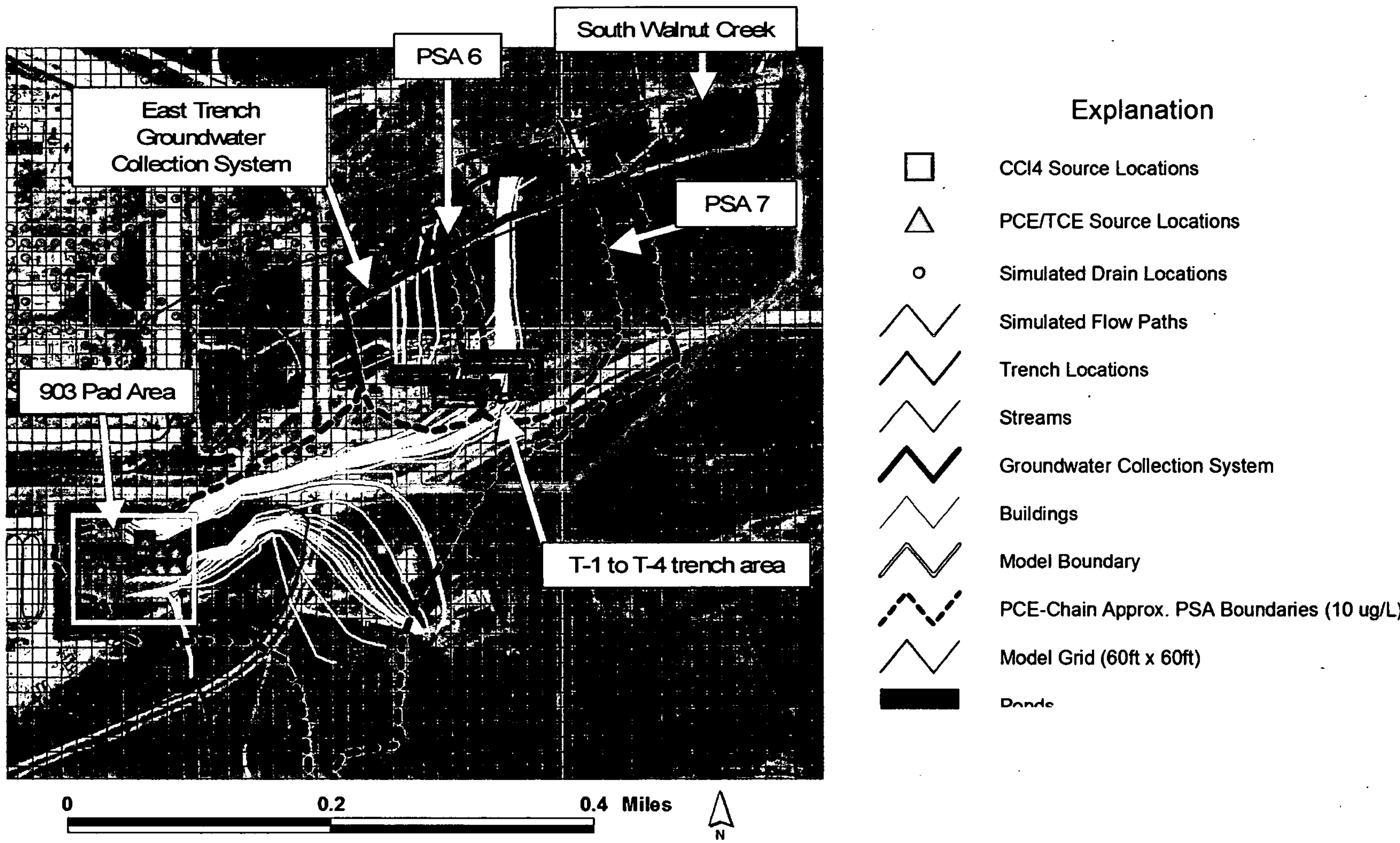

Figure 6.6. PSA 2N (and PSA 6 and PSA 7) - Simulated flow paths (after 42 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

Pad traveled primarily in the saturated higher conductivity unconsolidated material extending eastward along the center of the mesa.

Particles traveling in the lower conductivity weathered bedrock (no Arapahoe Sandstone) from the 903 Pad did not reach the East Trenches area within the time since VOCs were released.

6.2.1.1.4 Transport Model Results – Historical Conditions

Time-averaged concentrations at sample locations show PCE, TCE, and CCl_4 have been present above their draft surface water PRGs. TCE concentrations are the highest of the VOCs in the area and when coupled with a relatively low PRG , 0.19 mg/L, TCE is the contaminant most likely to reach a groundwater discharge area at or above its PRG.

The initial PSA 2N model reproduced overall average concentrations reasonably well, but failed to reproduce the high concentrations at down-gradient wells near the discharge area (23097, 23197, and 23397 along the eastern part of the East Trench groundwater collection system).

A subset model (PSA 6 and 7) was developed to better simulate down-gradient concentrations in the East Trenches source area. This model was based on particle flowpath results that indicated flow from the 903 Pad source travels to, and commingles with, the East Trenches source.

6.2.1.1.5 Transport Model Results – Closure Configuration

Sixteen closure configuration simulations were not run for for the PSA 2N model because initial modeling showed that long-term concentrations from the 903 Pad area would not result in down-gradient groundwater discharge concentrations greater than draft PRGs. Instead, the closure configuration simulation for the area was modeled using the PSA 6 and 7 sub-scale model.

6.2.1.2 PSA 6 and 7 (East Trenches Area – Sub-Scale Model)

A sub-scale model within the PSA 2N area was developed to better simulate several high concentration wells down-gradient of the East Trench groundwater collection system (PSAs 6 and 7 defined on Figures B-1 through B-7, in Appendix B). Though the 903 Pad area is not included in the sub-scale model, transport from the 903 Pad source was included using specified concentrations along the southwestern model boundary. The hydraulic conductivity distribution imported from the integrated flow model was modified based on conversations with SMEs involved with the construction of the East Trenches Groundwater Collection System and in an East Trenches Plume report (Kaiser-Hill, 1999). A 100 foot-wide zone of increased permeability produced higher discharge rates during installation of the East Trenches Groundwater Collection System. For the sub-scale model, a preferential pathway was assumed to occur between the T-1

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to T-4 trench area (Figure 6.6) and the set of observed high concentration wells (up to 6 mg/L) used to place the East Trench system. This zone was also assumed to extend at least to the B-2 Pond to account for observed VOC concentrations in this area. The hydraulic conductivity of this zone was increased only moderately above the average Arapahoe Sandstone unit value. This is reasonable given that the Arapahoe Sandstone hydraulic conductivity values range more than one order of magnitude over the Site (Kaiser-Hill, 2002). It should be recognized that the extents and depth of this higher permeability zone were assumed for this model only to the extent that they accounted for the higher concentration wells associated with Trench alignment. Effects of the assumed zone's northern and southern extent, connection to the B-ponds, vertical extent on transport, or flow in the area were not evaluated in this study.

6.2.1.2.1 Groundwater Flow Model Results

Simulated groundwater levels compared well against observed well water levels (Figure 6.7), though some residuals range up to 5 meters. This is likely due to the increased hydraulic conductivity zone, and assumptions about how flow in this bedrock zone discharges to the East Trench system, the B-2 Pond, and unconsolidated materials in the area.

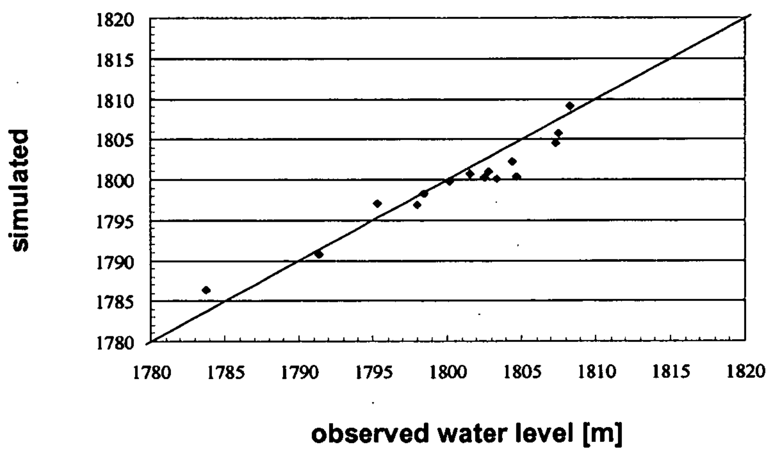

Figure 6.7. PSA 6 and 7 - Simulated versus average observed annual groundwater levels (meters above msl).

6.2.1.2.2 Particle Tracking Results – Historical Conditions

In contrast to the 903 Pad area, particles introduced in the PSA 6 and PSA 7 source areas (East Trenches, shown on Figure 6.6) preferentially traveled northward within the Arapahoe Sandstone layer, despite having been introduced into the lower unconsolidated material and upper weathered bedrock layers. This is partly due to the increased hydraulic conductivity zone that locally concentrates particles from the T-3/T-4 trenches towards the down-gradient high

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concentration wells. It is also due to portions of the T-1 to T-4 trenches that occur in areas where Arapahoe Sandstone subcrops beneath the unconsolidated material. As a result, it was hypothesized that a constant groundwater source at any of these trenches did not collect at the weathered bedrock interface, but instead moved into the bottom of the Arapahoe Sandstone, where it collected at the sandstone/claystone interface and resulted in a constant dissolved-phase VOC source.

Simulated transport pathways from the T-1 through T-4 trench area were also strongly controlled by the extent, orientation, and degree of subcropping of the Arapahoe Sandstone in this area. The thin unconsolidated material along the northern mesa hillside remained unsaturated, in part due to greater lateral drainage of the higher conductivity underlying Arapahoe Sandstone in this area.

This flow model was used for transport simulations for the PSA 2N area because it reproduced the observed concentration distribution better than the larger-scale PSA 2N model described previously.

6.2.1.2.3 Transport Model Results – Historical Conditions

Time-averaged concentrations at sample locations show PCE and TCE are present above their draft surface water PRGs. PCE and TCE were detected above draft surface water PRG levels (4.7 mg/L and 221 mg/L, respectively) within the PSA 6 and 7 areas. CCl_4 was detected above its draft surface water PRG level within the PSA 6 and 7 areas with individual sample results ranging to 3.8 mg/L. The high TCE concentrations combined with a relatively low PRG (0.19 mg/L for TCE versus 1.46 mg/L for PCE and 0.58 mg/L for CCl_4) makes it the contaminant most likely to reach a groundwater discharge area at or above its PRG.

The East Trenches Groundwater Collection System influences transport modeling in this area. The system was installed between February, and August, 1999 to intercept contamination migrating from the East Trenches to the discharge area. The modeling used time-averaged concentrations from wells prior to installation of the groundwater collection system for comparison to maximize the number of available data points. Several wells in the area with high concentrations (23097, 23197, 23397, and 23597) were installed to locate the system and were sampled only once in 1998. The wells located beyond the groundwater collection system nearer the discharge area showed post-remediation concentrations at the low end of the range of seasonal variability. As of 2002, the TCE concentration of influent to the system was in the 1 to 2 mg/L range. A higher resolution model would be necessary to evaluate groundwater collection system performance.

Simulations including the high conductivity zone reproduced the observed average concentrations well throughout the model area, including lower concentrations to the west of the zone. Sensitivity runs using more conservative

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and less conservative parameter values bracketed the time-averaged concentration distribution. The TCE results for high concentration and low concentration simulations are shown on Figure 6.8 and Figure 6.9.

The observed concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain; CCL_3 and CCL_2 for the CCl_4 degradation chain) was bracketed by the various sensitivity runs with the high source concentration (producing high daughter products) and low degradation (producing low daughter products) cases for the PCE degradation chain are shown on Figure D-1 and Figure D-2 of Appendix D. There were only three locations with low concentrations of VC, so only cis-1,2-DCE is shown for the PCE chain.

6.2.1.2.4 Transport Model Results – Closure Configuration

Under current conditions in the PSA 6 and 7 model area, groundwater flows in the lower weathered bedrock (Arapahoe Sandstone), north towards South Walnut Creek. Because the area did not change significantly under the proposed closure configuration flow conditions in the PSA 6 and 7 areas were largely unaffected.

Fourteen transport model sensitivity runs were simulated for the PCE/TCE and CCl_4 VOC chains. Due to a low water table at source cells in the upper weathered bedrock, the upper layer source scenario was not modeled. Due to numerical problems (high mass balance errors), the low dispersion case was also excluded. All runs were simulated for at least 100 years to establish steady long-term concentrations with time at the PSA extent along south Walnut Creek to the north.

The average simulated PCE and TCE groundwater concentration for all model runs at discharge areas are shown on Figure 6.10 and Figure 6.11. There were no locations where simulated PCE, or CCl_4 were above draft PRG values at groundwater discharge locations within the PSA 6 or 7 areas. Average simulated groundwater TCE concentrations, however, for all 14 runs at several groundwater discharge locations were above draft surface water PRG levels (0.19 mg/L) immediately down-gradient of the modeled high conductivity zone (Figure 6.11). This was consistent with the time-averaged concentrations in pre-trench wells near the high conductivity zone. Groundwater TCE concentrations were simulated above draft PRG values at the B-1 and B-2 Ponds.

The bar charts on Figure 6.12 show results for discharge locations impacted by CCl_4. Concentrations at these locations ranged from non-detect in some sensitivity runs, to near the draft surface water PRG (0.58 mg/L) for the high concentration case. This was consistent with time-averaged concentrations and was expected from the conceptual model of the area. Unlike PCE/TCE, the highest concentration source for CCl_4 was in PSA 6, west of the high conductivity zone that influences the higher PCE/TCE concentrations in PSA 7 (Appendix B).

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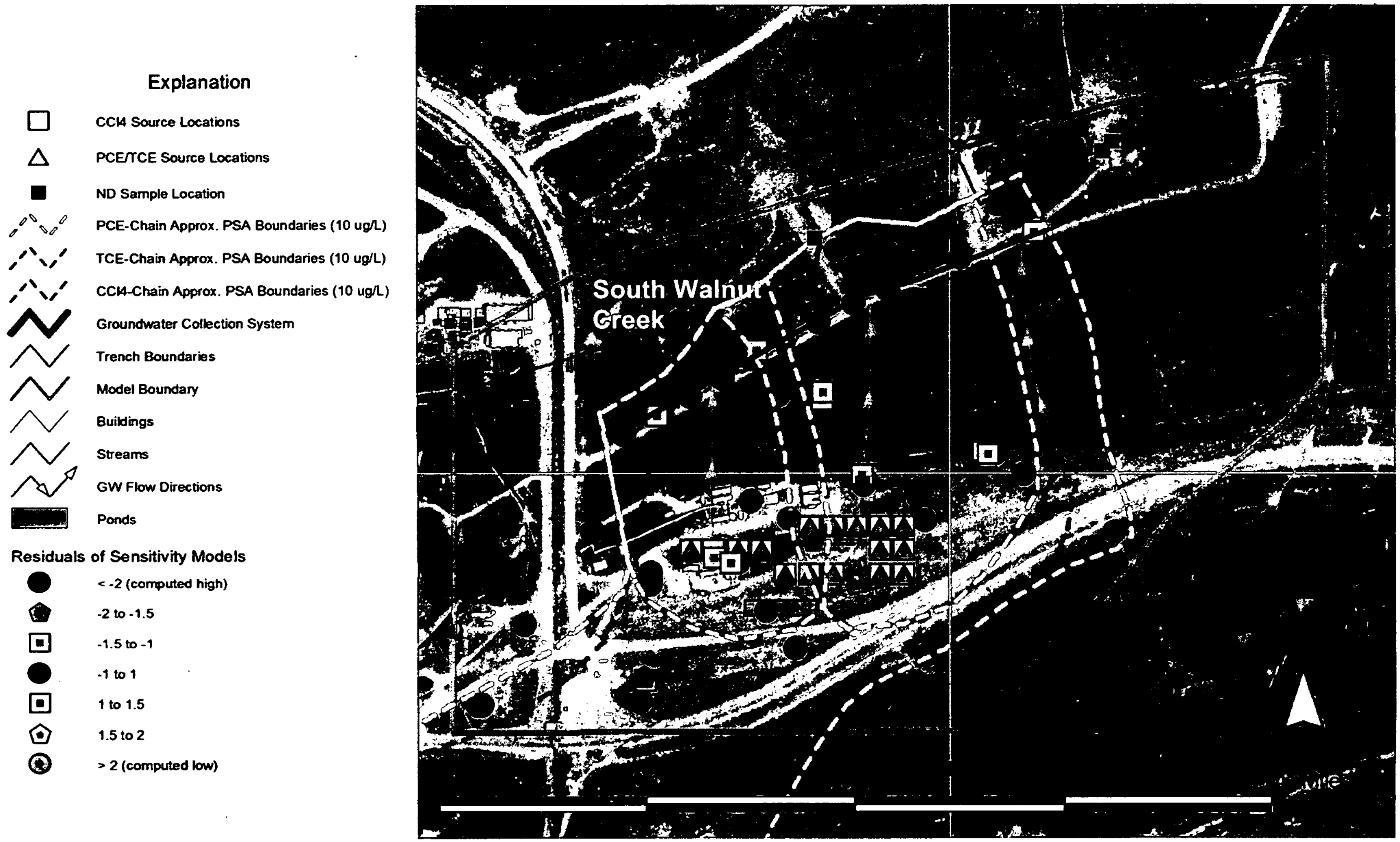

Figure 6.8. PSA 6 and 7 – Log residual concentrations. High predicted concentration (TCE) sensitivity run (high hydraulic conductivity).

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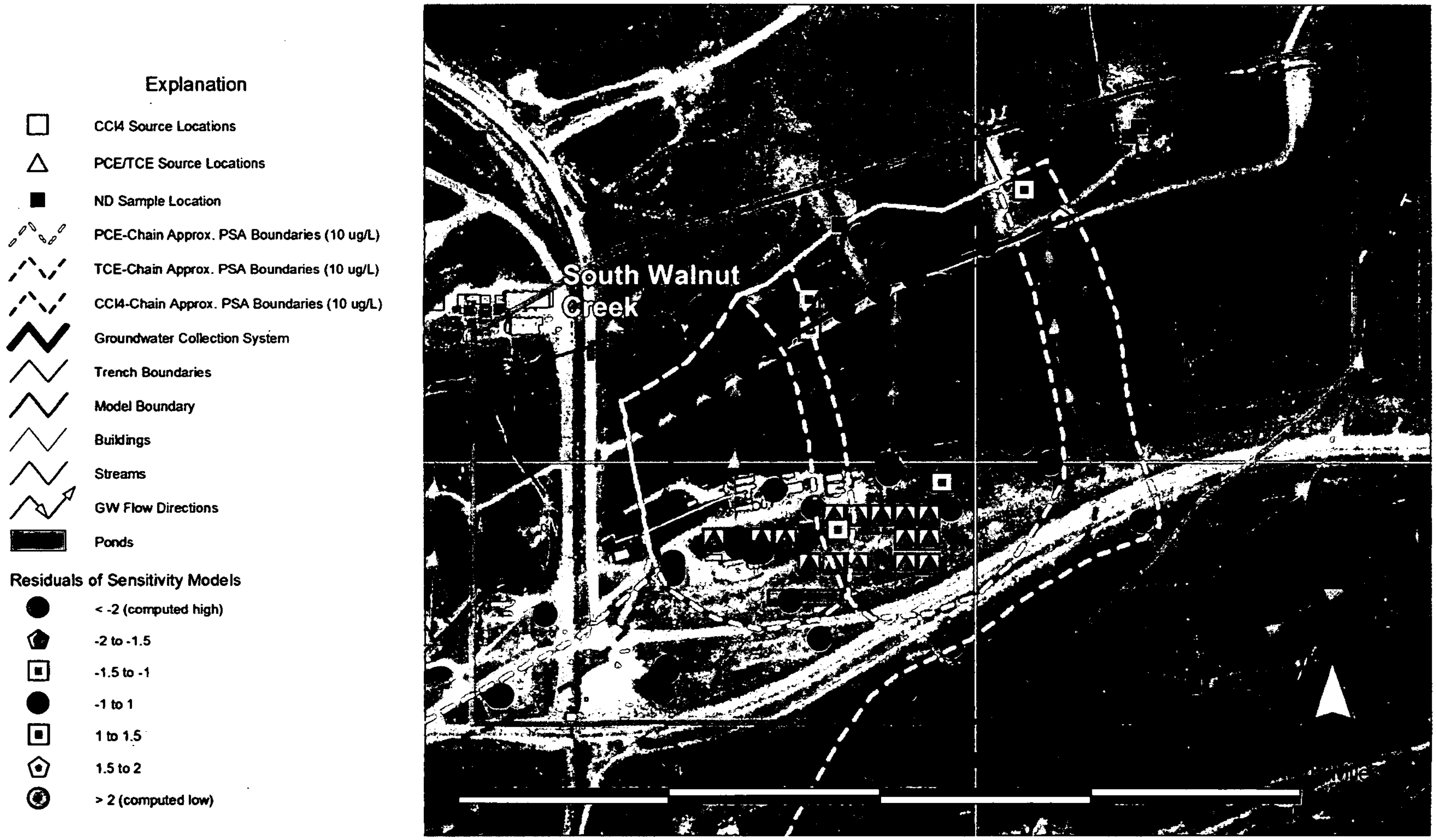

Figure 6.9. PSA 6 and 7 – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (low source concentration).

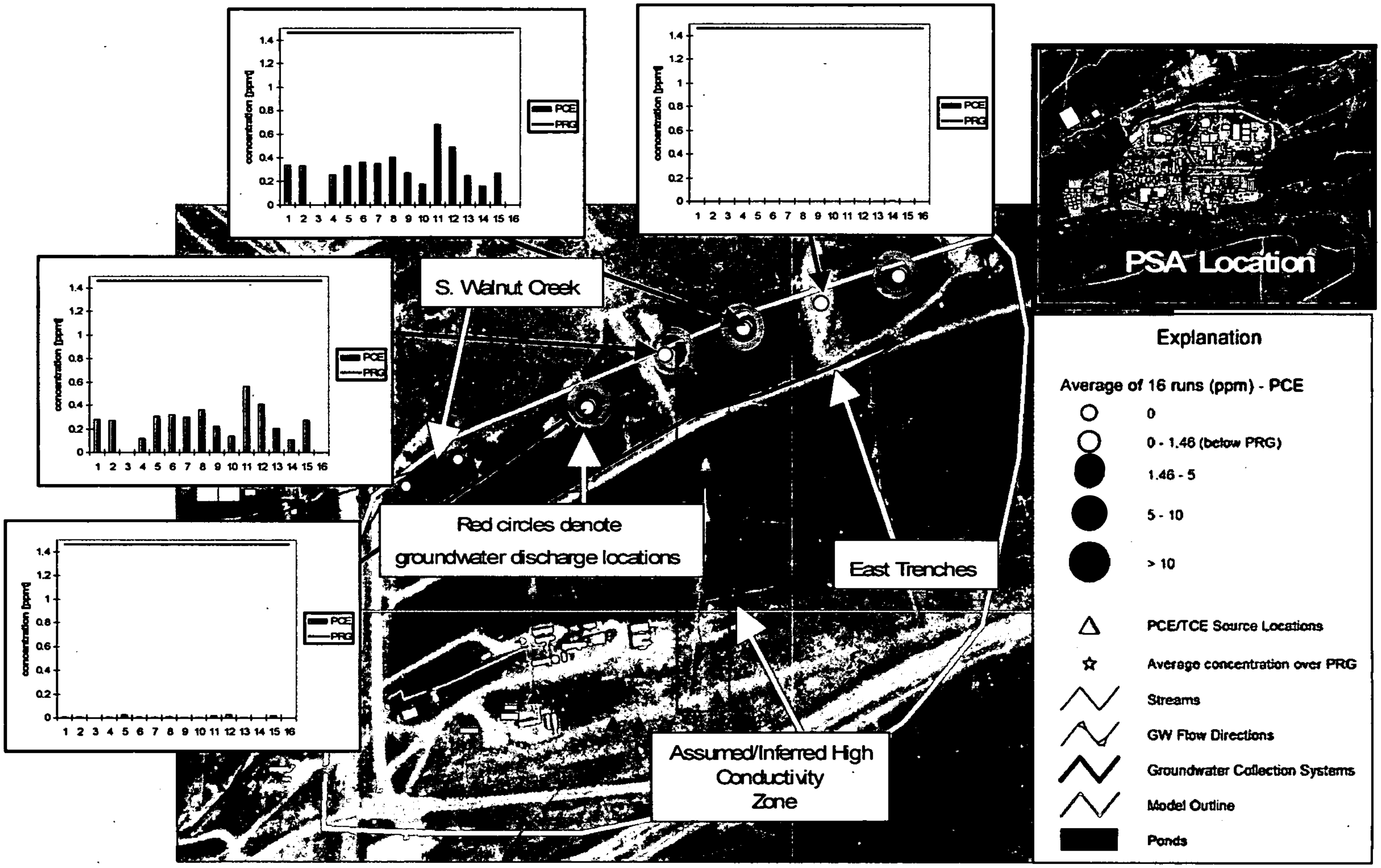

Figure 6.10. PSA 6 and 7 - Simulated PCE groundwater concentrations at discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

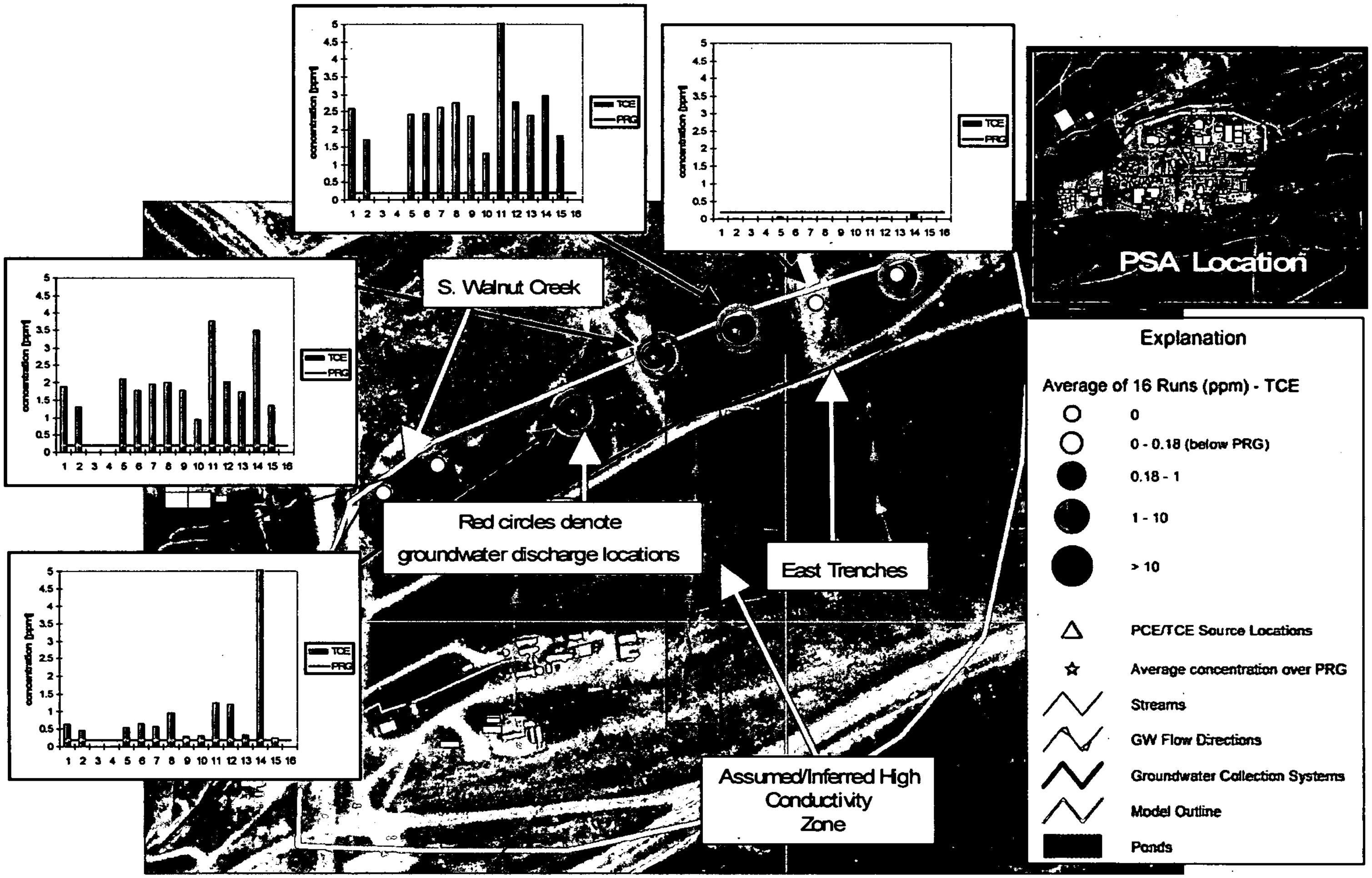

Figure 6.11. PSA 6 and 7 - Simulated TCE groundwater concentrations at discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

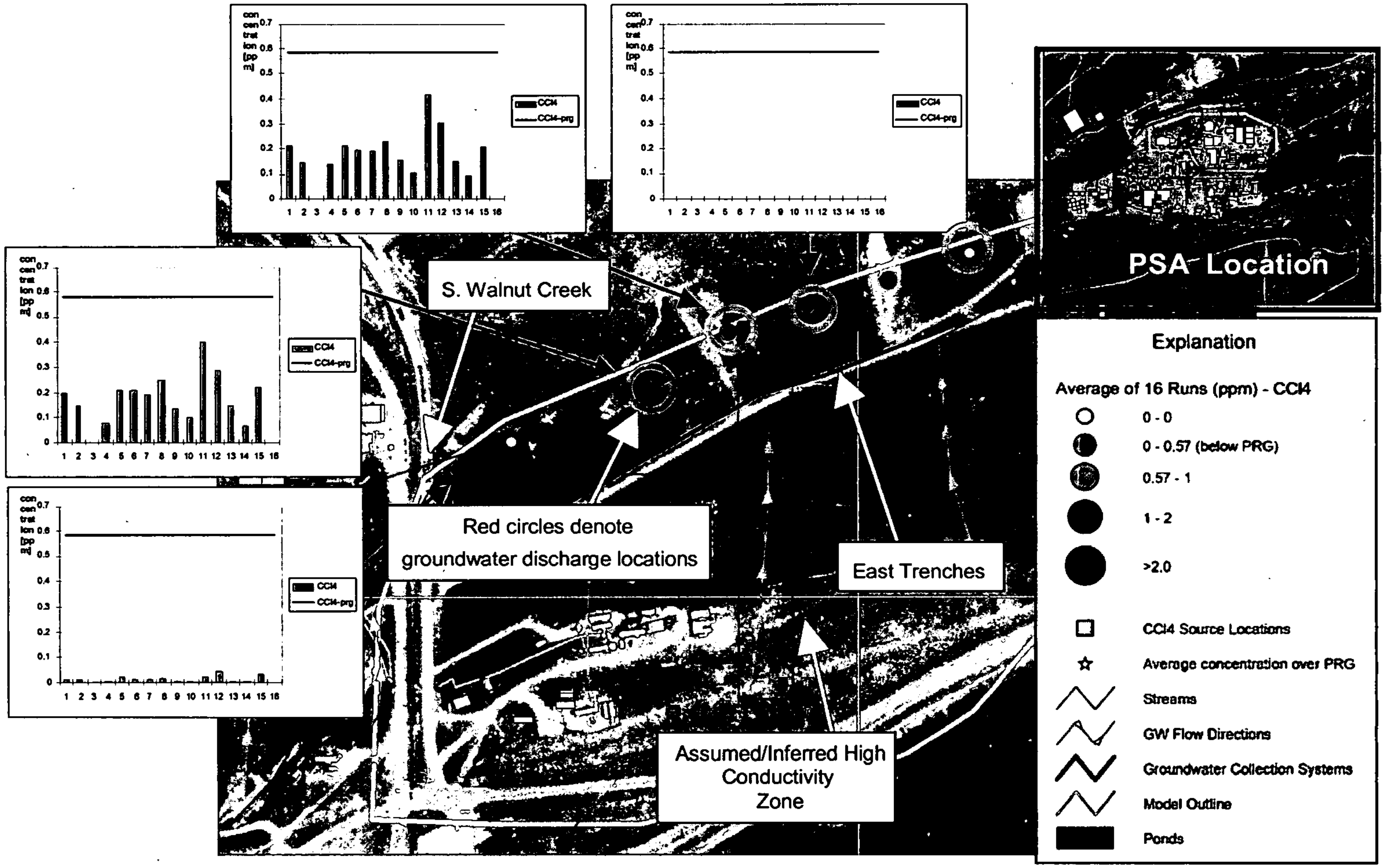

Figure 6.12. PSA 6 and 7 - Simulated CCl_4 groundwater concentrations at discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

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6.2.1.3 PSA 2S (Ryan's Pit/Southern 903 Pad Area)

The PSA 2S model area is located in the southeastern part of the VOC study area and is defined on Figure 6.1 and Figure 6.13.

6.2.1.3.1 Groundwater Flow Model Results

Constant hydraulic heads were specified along PSA 2S model boundary cells for all four saturated zone layers (Figure 6.13). Constant hydraulic heads along the Woman Creek boundary were assigned values near ground surface. This was valid because they represent the lowest heads in the model area and did not affect up-gradient flow calculations.

Average annual groundwater levels in the model area were reproduced reasonably well (Figure 6.14). Residuals ranged from 1 to 2 meters.

Simulated model water balance results showed that water entered the model primarily as direct recharge and to a lesser extent by lateral inflow (i.e., constant head cells). Discharge occurred mostly by ET near Woman Creek. Integrated flow model results indicated only localized and intermittent (high groundwater levels) discharge occurred to the SID in this model area.

6.2.1.3.2 Simulated Groundwater VOC Sources

The two VOC source locations inferred for the PSA 2S area were associated with the 903 Pad and Ryan's Pit areas. They were documented as Priority 1 releases in the HRR database (Appendix A, reference numbers 34, 39, 178, 179, and 30, 31, 32, and 33). Solvents, paint thinners, diesel fuel, and other construction related chemicals/materials were disposed of at trench T-2 (Ryan's Pit) until 1970. The pit was backfilled in 1971. In the 903 Pad area, drums were stored (IHSS 112 and 155) from 1958 to 1967. Leaking drums were noted in 1964. They were removed and the asphalt pad was completed in 1969. Despite soil remediation in the area, it was hypothesized that VOCs released in the area likely migrated downward into the groundwater as DNAPL and collected above the weathered bedrock (claystone in this area). It is also possible that DNAPL entered the weathered bedrock and acts as a constant dissolved-phased VOC source in groundwater given the steady time-averaged concentrations in down-gradient wells.

6.2.1.3.3 Particle Tracking Results – Historical Conditions

Inferred VOC sources were simulated in both the lower unconsolidated deposits and in the upper weathered bedrock at both the 903 Pad and at Ryan's Pit at locations shown on Figure 6.15. The long extent of PSA 2S also supported introducing a source into the unconsolidated material so that simulated VOCs would reach the extent of the PSA. Multiple inferred VOC source locations were evaluated in the 903 Pad area.

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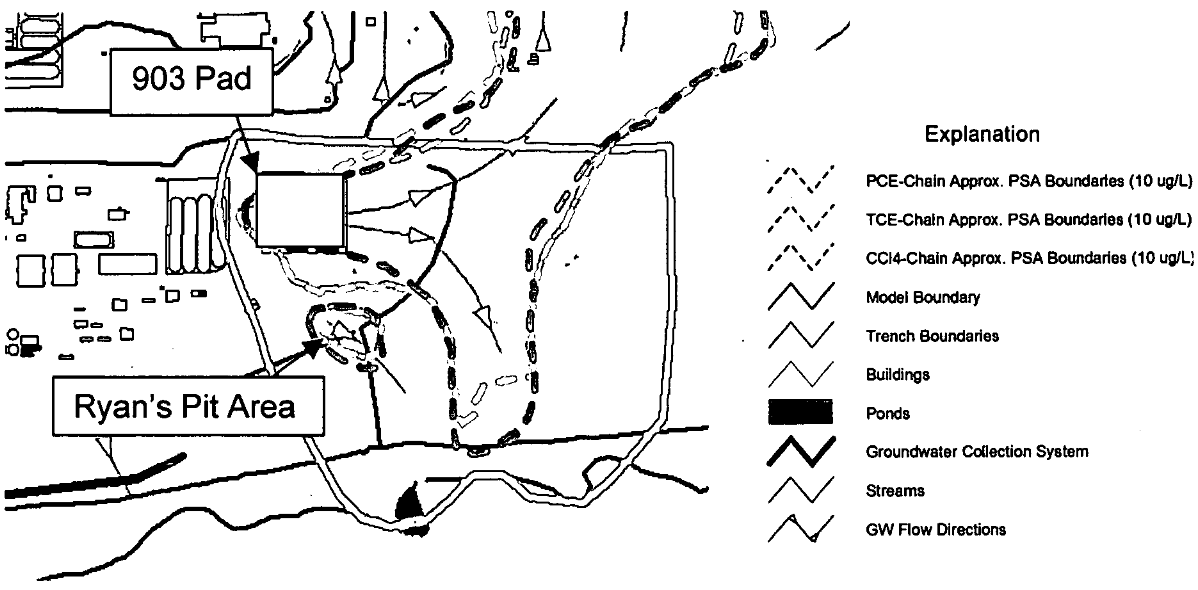

Figure 6.13. PSA 2S – Model area and PSAs

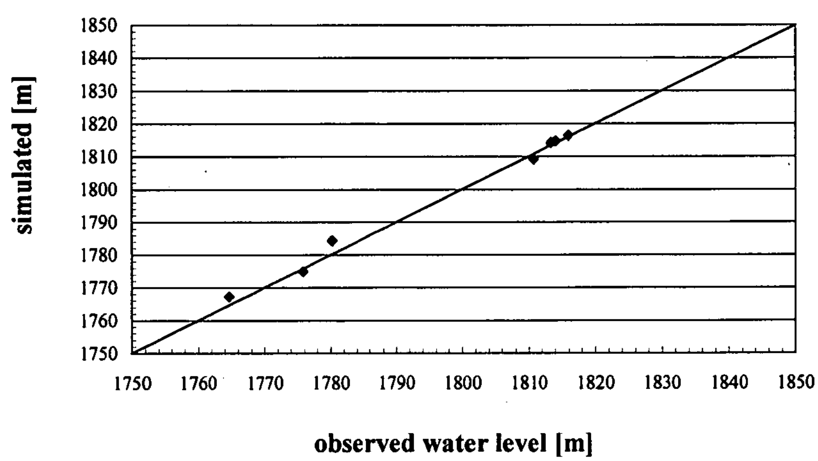

Figure 6.14. PSA 2S - Simulated versus average observed annual groundwater levels (meters above msl).

Calculated flow paths and travel distances agreed well with the inferred VOC source locations and release times for PSA 2S and PSA 3 (Ryan's Pit) (Figure 6.15). Particles introduced in the lower unconsolidated material traveled to the PSA 2S and PSA 3 extents within the assumed 42-year travel time. Particles introduced into the upper weathered bedrock did not reach the assumed PSA extent just above the SID because the hydraulic conductivity of the weathered bedrock in this area is low compared to the unconsolidated material. Results also showed that some of the particles introduced into the lower unconsolidated material migrated into the lower weathered bedrock layer east of the 903 Pad area due to downward hydraulic gradients near the assumed sources.

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Particle paths were affected by two main factors, unconsolidated thickness and the degree to which the unconsolidated material is unsaturated. The unconsolidated material thickness increases east of the 903 Pad. In the flow model, this caused groundwater flows to be directed eastward first, then to the southeast towards Woman Creek. As particles traveled within the hillslope towards Woman Creek flow paths became irregular (Figure 6.15). This was because the unconsolidated material is unsaturated in this area due to shallower depths to bedrock. Results showed that particle pathways are consistent with the assumed PSA 2S extents.

6.2.1.3.4 Transport Model Results – Historical Conditions

Time-averaged concentrations at sample locations show PCE, TCE, and CCl_4 are present above their draft surface water PRGs. Time-averaged TCE concentrations are highest in PSA 2S, especially in the Ryan's Pit area. As a result, TCE is the contaminant most likely to reach groundwater discharge areas at or above its PRG.

Sensitivity simulations indicated that time-averaged TCE concentrations within PSA 2S could be reproduced (as shown on Figures 6.16 and 6.17). Results indicated that the high hydraulic conductivity value sensitivity run produced conservatively high concentrations at sample locations. The increased groundwater velocities, due to higher conductivity values, produced higher concentrations at down-gradient locations, and prevented more significant degradation losses. Specifying low hydraulic conductivity values under-predicted time-averaged concentrations within the PSA.

The observed concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain; chloroform and methylene chloride for the CCl_4 degradation chain) was bracketed by the various sensitivity runs. These sensivity runs included high conductivity and high degradation (producing high daughter products) and low degradation (producing low daughter products) cases for the PCE degradation chain. The results are shown on Figure D-3 and Figure D-4 of Appendix D.

6.2.1.3.5 Transport Model Results – Closure Configuration

Flow conditions did not change significantly under the closure design (except for the 903 Pad area).

Sixteen transport simulations were simulated for the PCE/TCE degradation chain. All runs were simulated for 450 years to establish steady long-term concentrations with time at the PSA extent along Woman Creek to the south. Closure configuration simulations indicated steady TCE concentrations, at groundwater discharge locations, were attained after hundreds of years. One of the reasons it takes so long for this PSA to reach steady conditions is the relatively slow travel velocity in the bedrock and longer distances from the source

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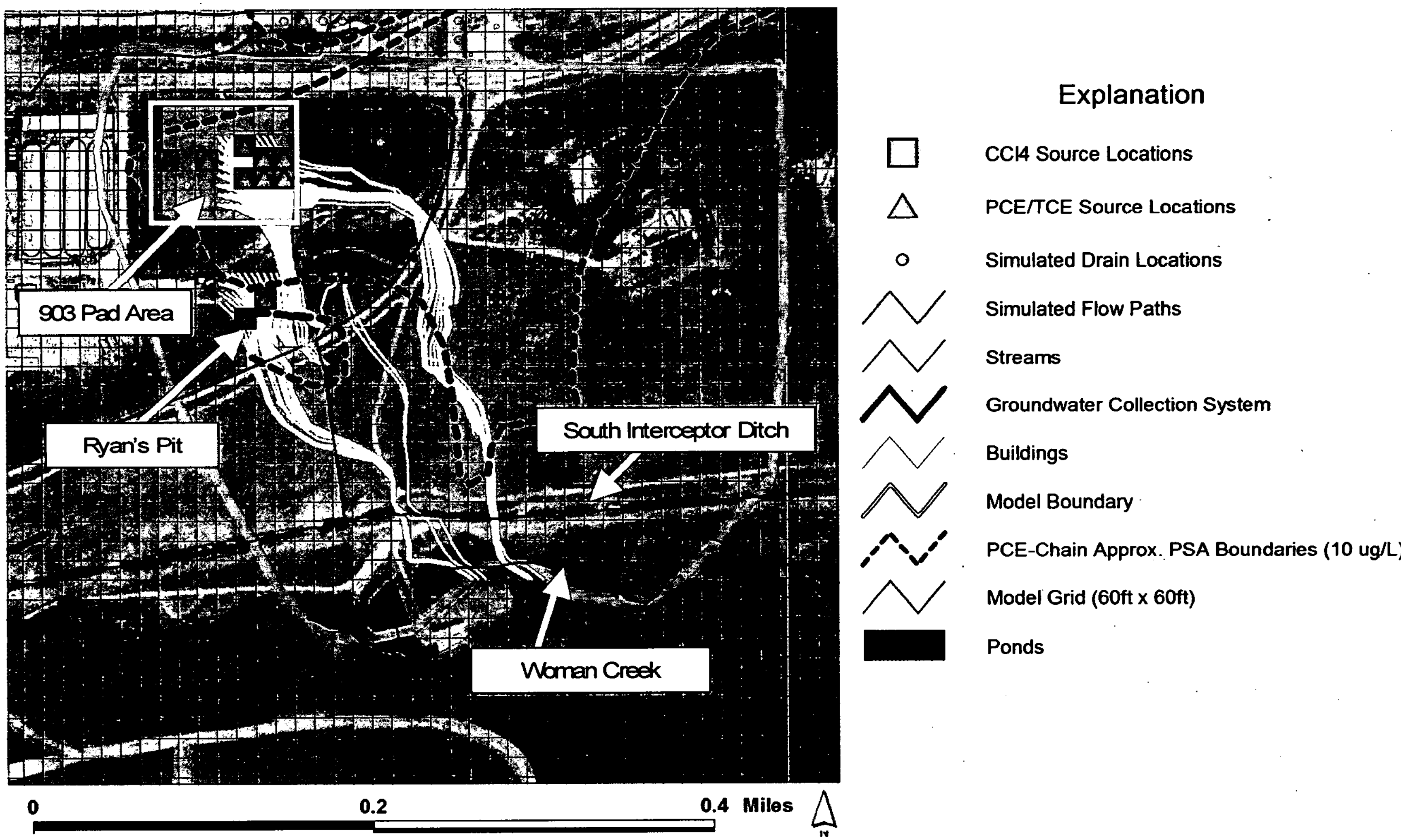

Figure 6.15. PSA 2S - Simulated flow paths (after 42 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

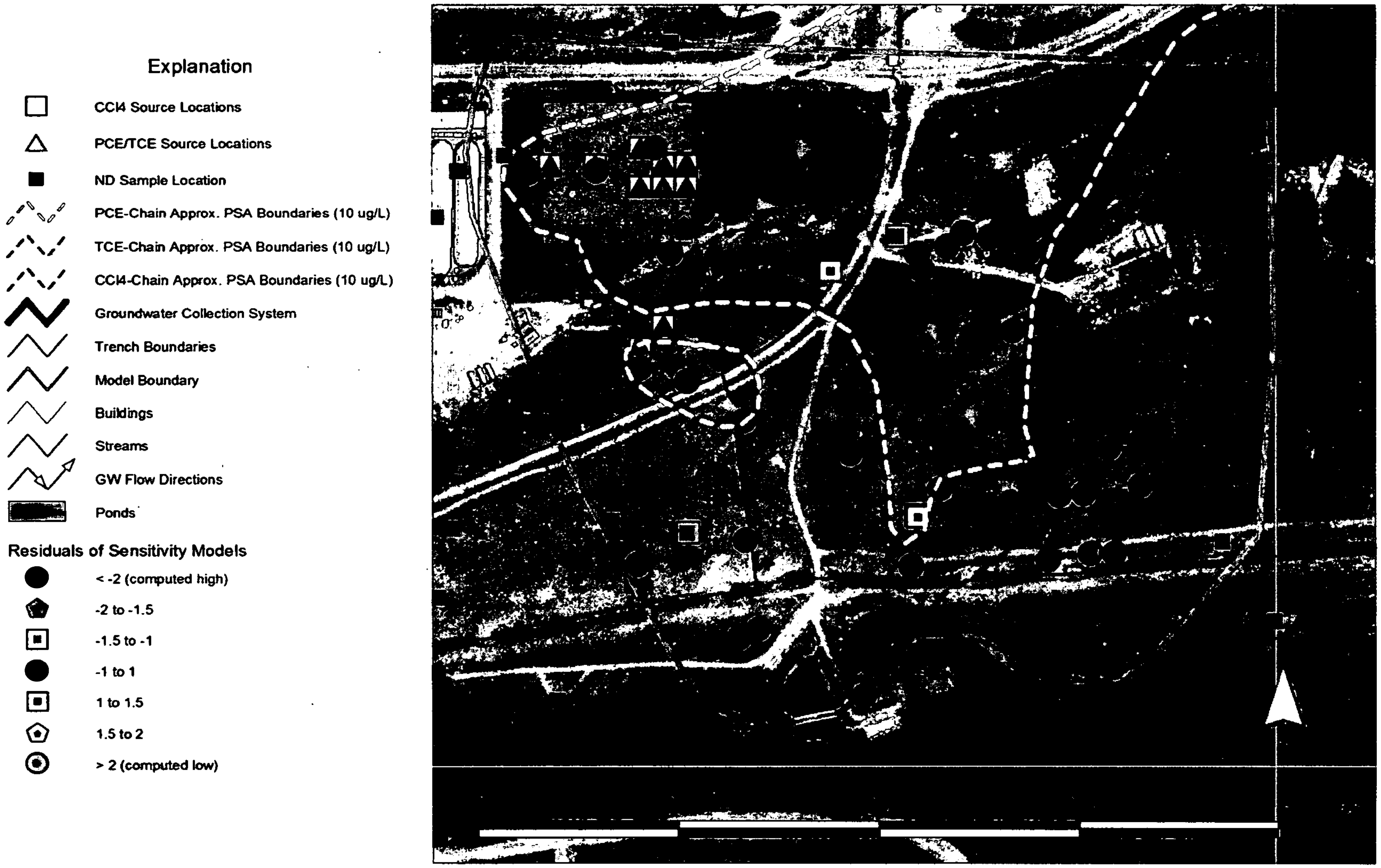

Figure 6.16. PSA 2S – Log residual concentrations. High predicted concentration (TCE) sensitivity run (high hydraulic conductivity).

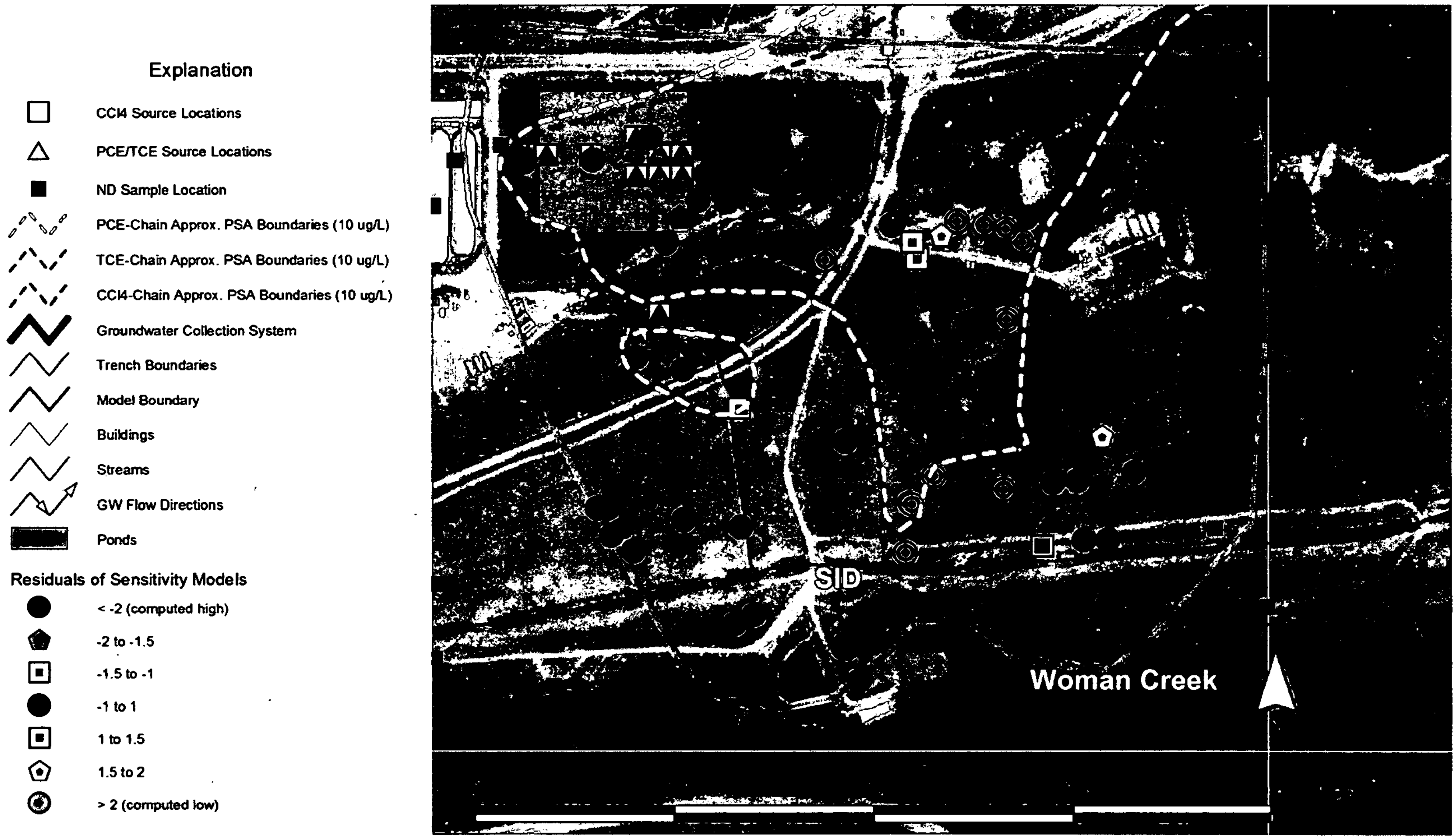

Figure 6.17. PSA 2S – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (low hydraulic conductivity).

areas to stream locations. The average simulated groundwater concentration for each of the model runs at groundwater discharge areas for TCE is shown on Figure 6.18.

Sixteen transport simulations were also simulated for the CCl_4 degradation chain. All runs were simulated for at least 450 years to establish steady long-term concentrations with time at the PSA extent along Woman Creek to the south. The average simulated groundwater concentration for each of the model runs at groundwater discharge areas for CCl_4 is shown on Figure 6.19.

The bar charts on Figure 6.18 and Figure 6.19 show long-term simulated groundwater discharge concentrations for the 16 closure configuration runs for TCE in the PSA 2S area. Simulated TCE concentrations (averaged from all 16 runs), were greater than draft surface water PRG (0.19 mg/L) at a number of locations along the dirt road-side drainage ditch that runs northeast to southwest, down-gradient from the 903 Pad. Integrated flow modeling results, however, indicated that discharge only occurred along this drainage near its confluence with the SID. The average of all the simulated closure-condition TCE and CCl_4 groundwater concentrations at discharge locations along Woman Creek were below draft surface water PRG.

Mass flux from the transport model indicated that the simulated dominant loss mechanisms for VOCs were ET and biodegradation (Figure 6.20 and 6.21).

6.2.1.4 PSA 5 (Mound Groundwater Collection System Area)

The PSA 5 model area is located in the northeast part of the Site and is defined on Figure 6.1 and Figure 6.22.

6.2.1.4.1 Groundwater Flow Model Results

Constant head boundaries for PSA 5 were placed at the western and southern up-gradient boundaries where flow enters the model, as well as the northern down-gradient boundary where flow exits the model. Results of the simulated water balance indicated most inflow occurred via recharge, and less occurred through up-gradient constant head cells. Groundwater discharged as baseflow, ET, and as groundwater to the East Mound collection system. Simulated heads compared well with observed groundwater water levels (as shown on Figure 6.23). Residuals ranged from one to two meters.

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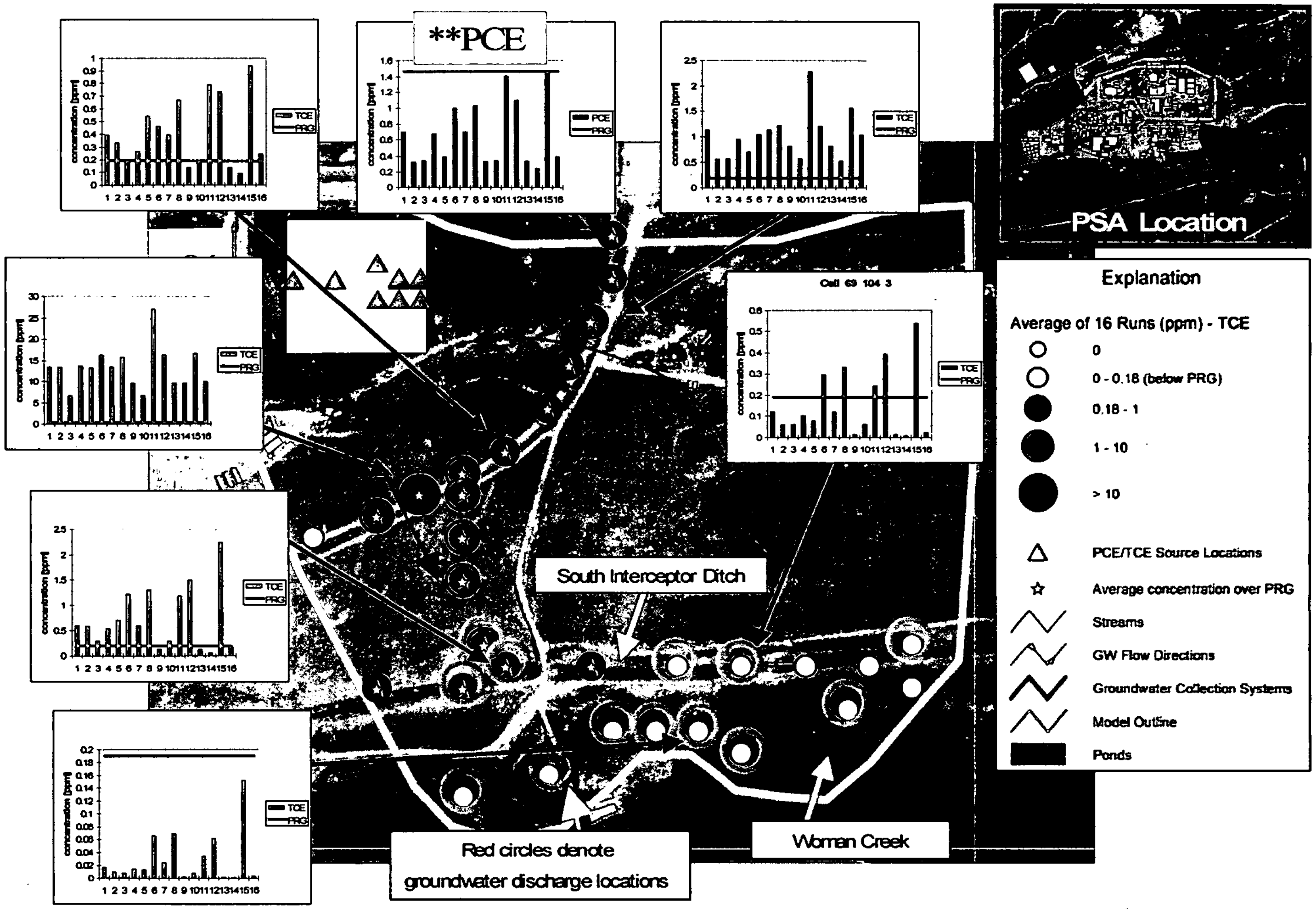

Figure 6.18. PSA 2S - Simulated TCE groundwater concentrations at discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

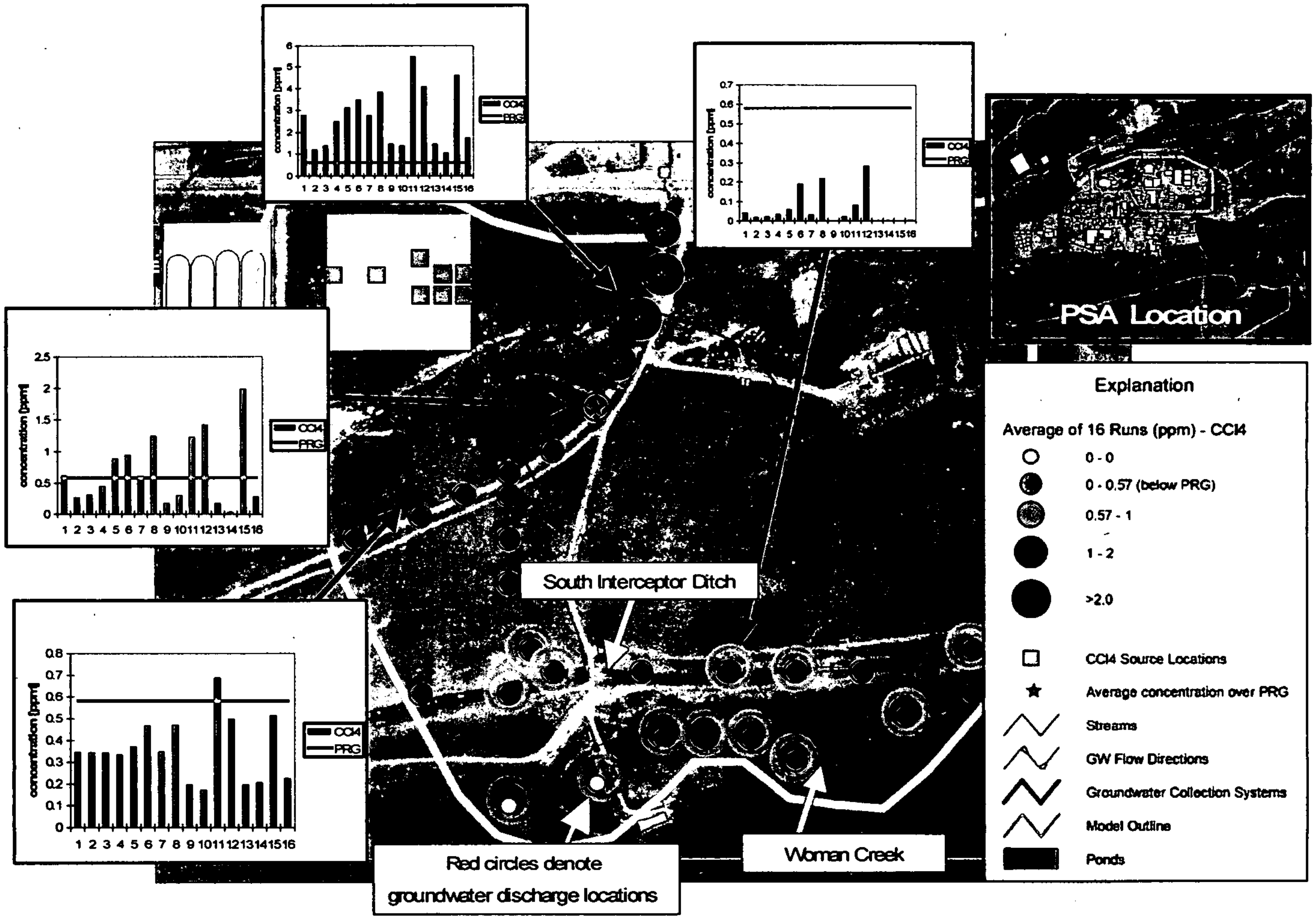

Figure 6.19. PSA 2S - Simulated CCl_4 groundwater concentrations at discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

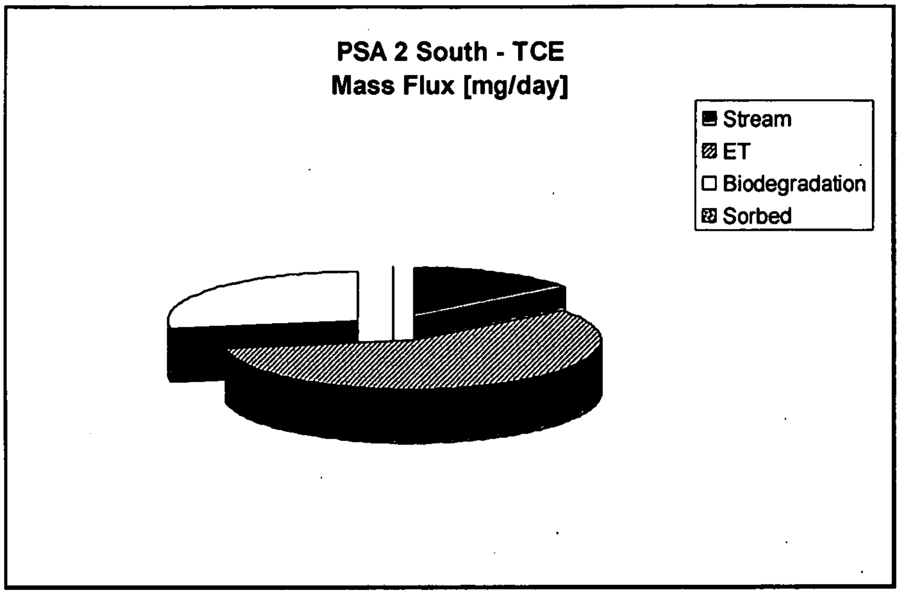

Figure 6.20. PSA 2S - Steady-state mass flux for TCE.

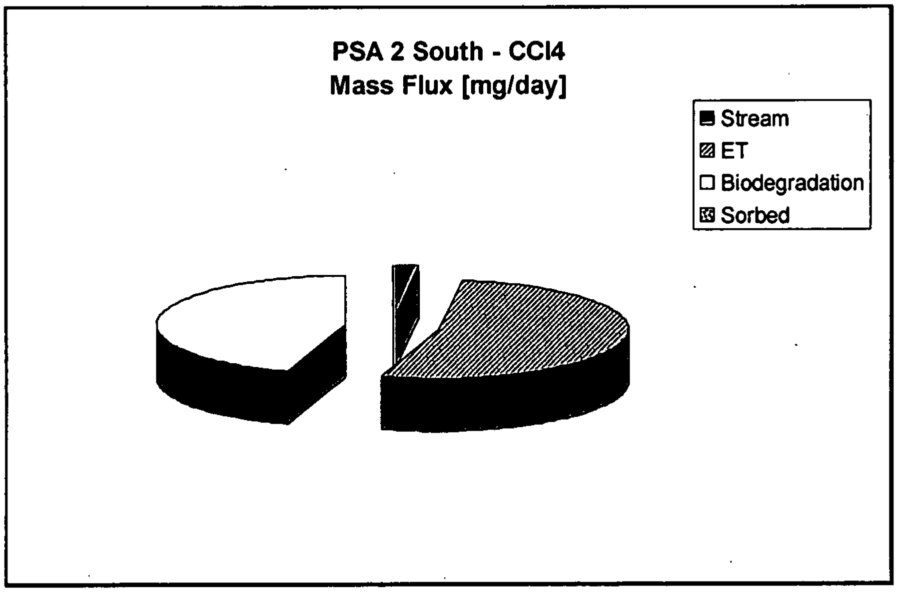

Figure 6.21. PSA 2S - Steady-state mass flux for CCl_4.

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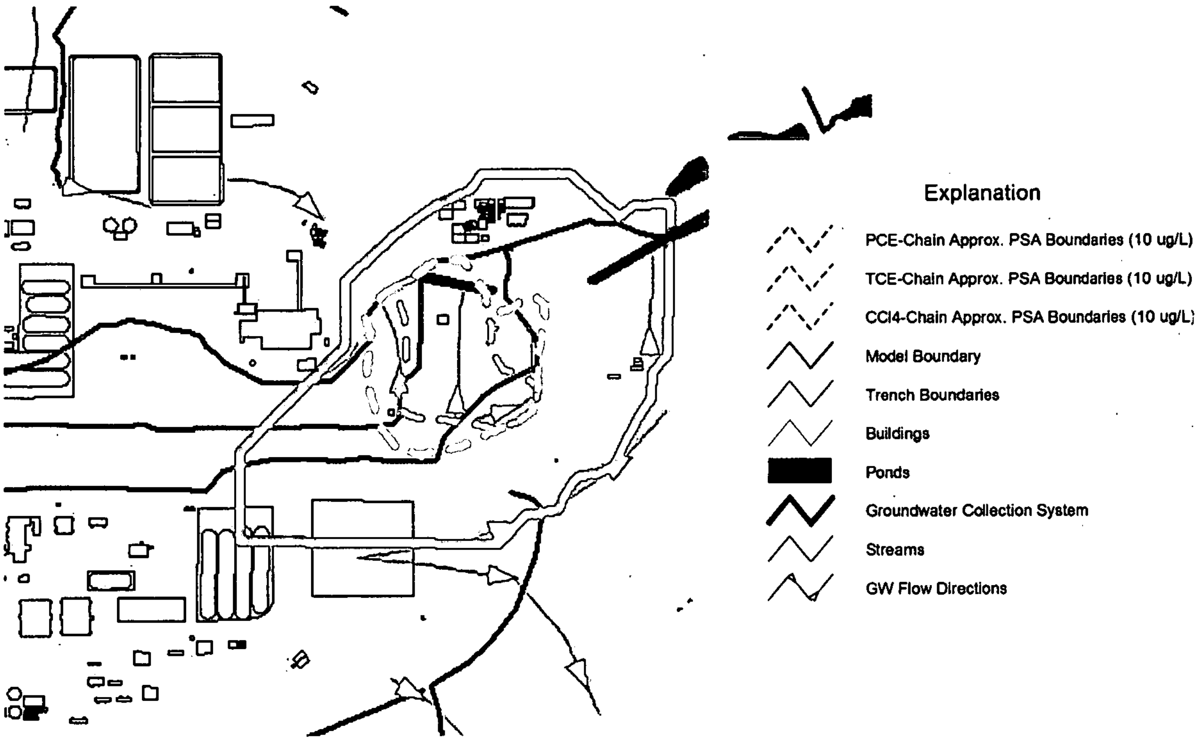

Figure 6.22. PSA 5 - Model area and PSA.

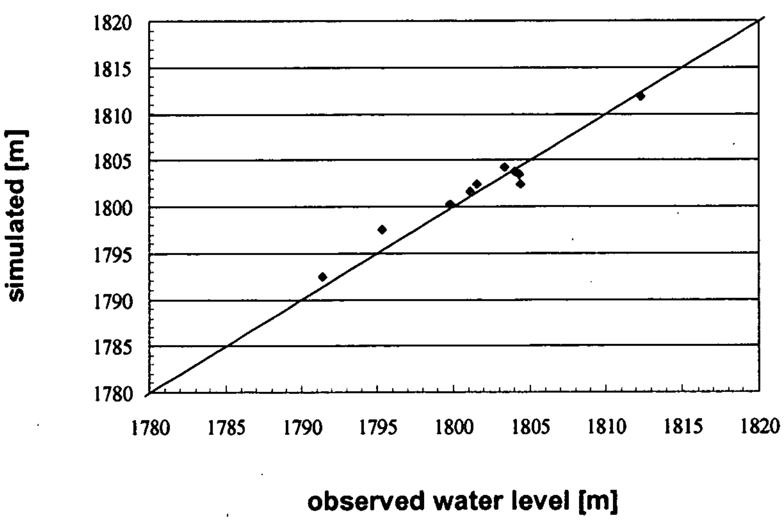

Figure 6.23. PSA 5 - Simulated versus average observed annual groundwater levels (meters above msl).

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6.2.1.4.2 Simulated Groundwater VOC Sources

The primary VOC source for PSA 5 model area was the Mound Site (drum storage area) as described in a final report for the Mound Site Plume Project by IT Corporation (1998). A secondary source was also introduced in a former Oil Burn Pit area (IHSS 153) (described in the HRR database in Appendix A).

PSA 5 contains five Priority 1 Releases, three in the up-gradient Mound Trenches area and two down-gradient near the Mound groundwater collection system (Appendix A, References 35, 36, 41 of the HRR VOC Summary Table). Drums were placed at the Mound Site from 1954 to 1958. Some of the drums contained lathe coolant (a mixture of hydraulic oil and CCl_4) and others contained PCE (Kaiser-Hill, 1998a). The drums were removed in 1970 but up to 10% of the drums (of the 1405 total) were suspected to have leaked. Removal of VOC contaminated soil was completed in 1997 (Kaiser-Hill, 1998a). Even though soil was excavated and remediated from the source area, the VOCs of concern are denser than water (DNAPL) and migrate downward through permeable materials until reaching a low permeability layer. It is likely that contaminants have migrated through the unconsolidated material to the upper weathered bedrock. In areas where the soil was not completely removed and remediated, residual NAPL is likely present, acting as a persistent long-term source. This is supported by time-series plots of concentration data from wells near the source areas that do not show a decreasing trend with time.

The three up-gradient Priority 1 releases (Mound Site) are closely located. They were simulated with constant PCE sources in two adjacent model cells (Figure 6.24). In this model area, the unconsolidated deposits remain unsaturated in many areas. As a result, inferred sources were specified in the weathered bedrock. There was no need to introduce TCE as an additional parent at the Mound source location based on the observed concentration distribution.

Two wells were recently installed (in 2003) to investigate a suspected source (the Oil Burn Pit, IHSS 153) west of the Mound Site. Groundwater samples from well 91103, located in the source area, showed a PCE concentration of 18 mg/L and a TCE concentration of 11 mg/L. Well 91203, located just north of the source area, showed a PCE concentration of 0.004 mg/L. A PCE/TCE source was inferred at the higher concentration well location.

6.2.1.4.3 Particle Tracking Results – Historical Conditions

Particles were introduced in the upper weathered bedrock at the model sources and allowed to travel for 42 years (Figure 6.24). Particle tracking results indicated that simulated flow directions agreed well with assumed locations, depths, and release timing of the PSA sources. Particles introduced at the drum storage area traveled north in the weathered bedrock where they were intercepted by the Mound Groundwater Collection System. Particles from the former Oil Burn Pit traveled northwest and discharged to South Walnut Creek, west of the Mound Groundwater Collection System. Thin unconsolidated

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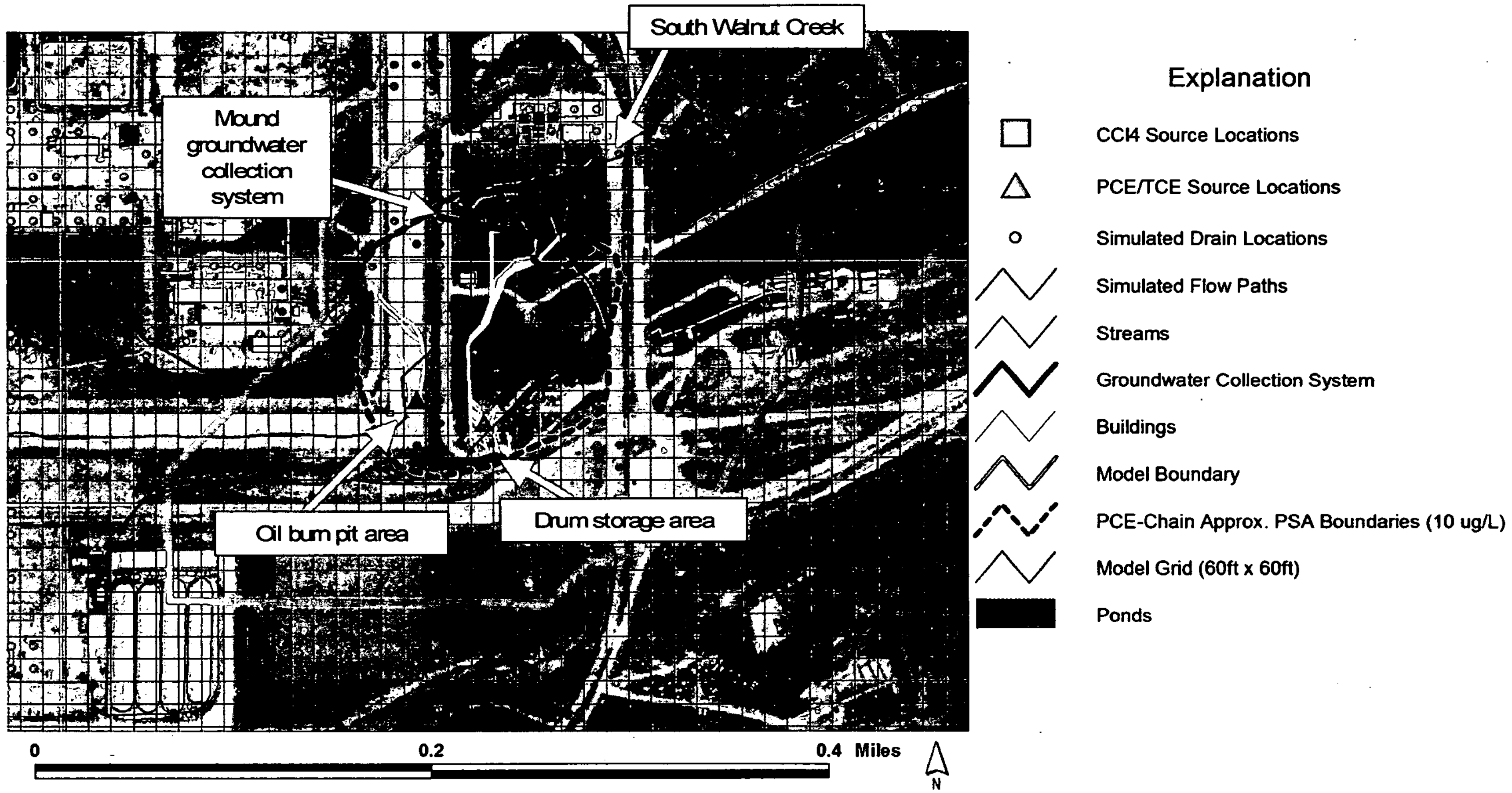

Figure 6.24. PSA 5 - Flow paths (after 42 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

material (<2 meters) on the hillslope north of the assumed sources was unsaturated. This forced groundwater to flow mainly within the bedrock in this area. The northeast trending Arapahoe Sandstone caused particles to flow eastward when intercepted.

6.2.1.4.4 Transport Model Results – Historical Conditions

Time-averaged concentrations at sample locations show PCE and TCE are present above their draft surface water PRGs. Time-averaged PCE and TCE concentrations (65.2 mg/L and 3.8 mg/L) were greater than the draft surface water PRG levels (1.46 mg/L and 0.19 mg/L, respectively) within the PSA 5 area.

The highest time-averaged CCl_4 concentration is below its PRG. As a result CCl_4 was not modeled. Additionally, simulated sources were not inferred for the two down-gradient Priority 1 releases. One was associated with well 3586, which has an average VC concentration above its PRG value but the concentrations in the well exhibited a declining trend that is now below the PRG. The other is to the northeast in an area of very low concentrations.

A total of 14 sensitivity runs using more conservative and less conservative parameter values bracketed the time-averaged concentrations. The modeled contamination distribution for most simulation runs extends laterally beyond the 10 ug/L PSA outline. Additional data from the new wells to the west and the reports of VOC odors from soil digging to the east support these results. The TCE results for high hydraulic conductivity and low hydraulic conductivity simulations are shown on Figures 6.25 and 6.26. Sensitivity runs bracket the observed daughter product concentrations in the model area except for the high VC area north of the treatment system (well 3586).

The observed concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain) was bracketed by the various sensitivity runs with the high hydraulic conductivity (producing high daughter products) and low degradation (producing low daughter products) cases for the PCE degradation chain. The results are shown on Figure D-5 and Figure D-6 of Appendix D.

6.2.1.4.5 Transport Model Results – Closure Configuration

Under current conditions groundwater flows to the north from the Mound Site and northwest from the Oil Burn Pit towards South Walnut Creek in the PSA 5 model area. Flow was primarily in the weathered bedrock, which occurs at shallow depths along the hillslope. Under the proposed closure configuration, South Walnut Creek along the northwest model boundary area will be re-graded. Simulations indicated that the closure configuration modifications redirect the current northward flow from the Mound Site to be more northwest.

A total of 16 transport models were simulated. All runs were simulated for at least 100 years to establish steady long-term concentrations with time at the PSA

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Explanation

- CCl4 Source Locations
- PCE/TCE Source Locations
- ND Sample Location
- PCE-Chain Approx. PSA Boundaries (10 ug/L)
- TCE-Chain Approx. PSA Boundaries (10 ug/L)
- CCl4-Chain Approx. PSA Boundaries (10 ug/L)
- Groundwater Collection System
- Trench Boundaries
- Model Boundary
- Buildings
- Streams
- GW Flow Directions
- Ponds

Residuals of Sensitivity Models

- < -2 (computed high)
- -2 to -1.5
- -1.5 to -1
- -1 to 1
- 1 to 1.5
- 1.5 to 2
- > 2 (computed low)

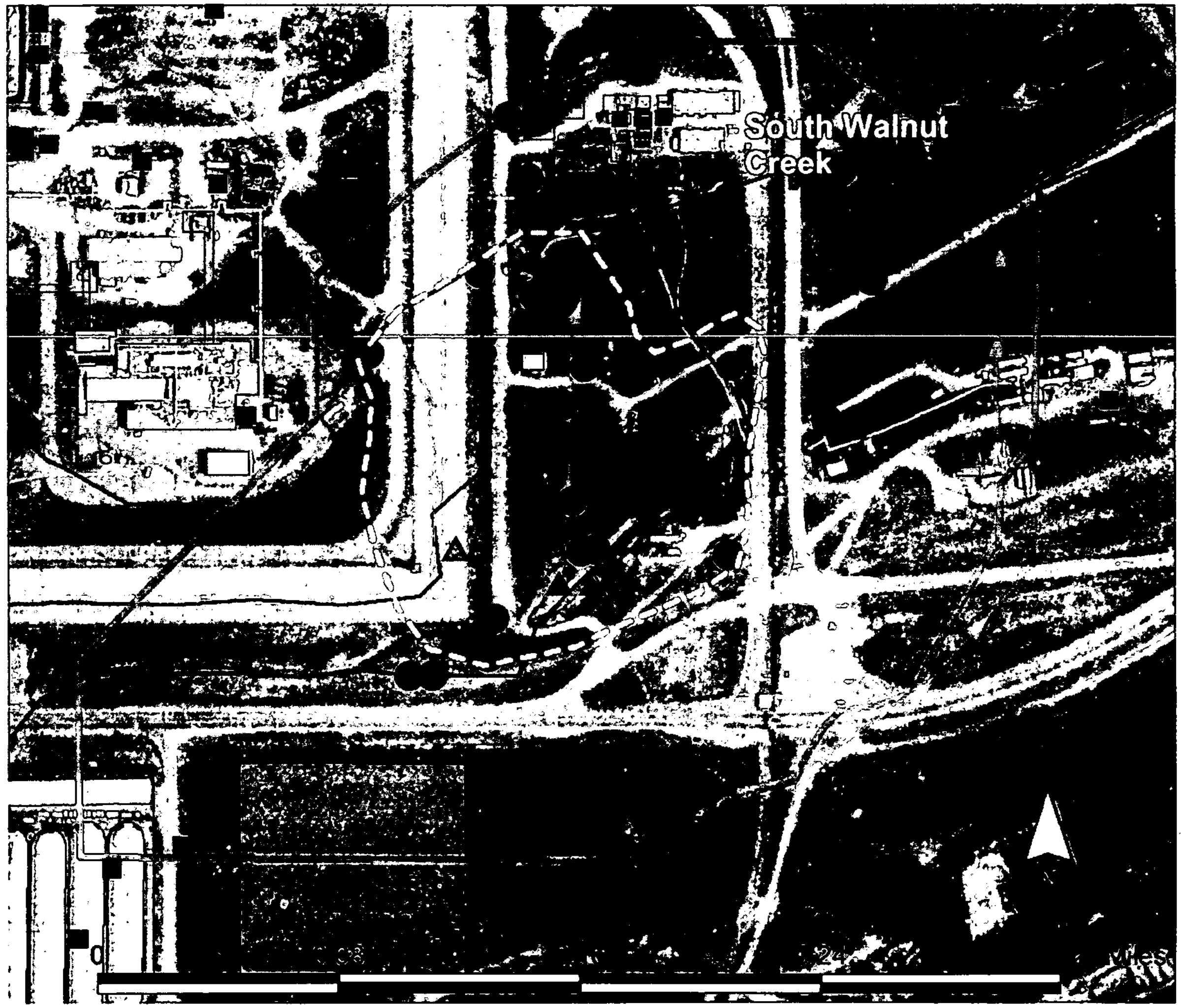

Figure 6.25. PSA 5 – Log residual concentrations. High predicted concentration (TCE) sensitivity run (high hydraulic conductivity).

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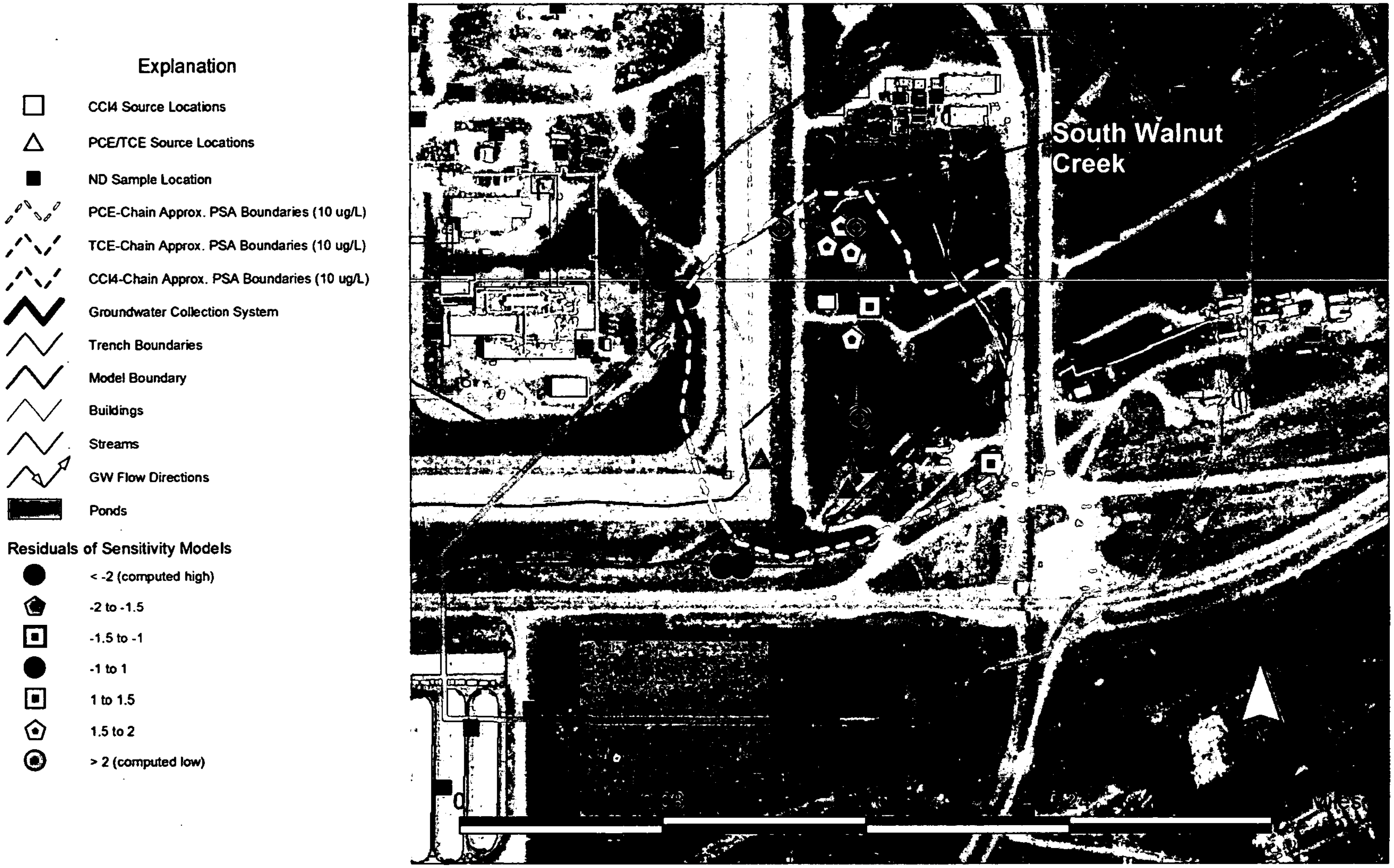

Figure 6.26. PSA 5 – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (low hydraulic conductivity).

extent along South Walnut Creek to the north and northwest. Steady-state conditions took at least 60 years to develop at all stream locations for this PSA. The average simulated groundwater concentration for each of the model runs at integrated flow groundwater discharge areas for PCE and TCE are shown on Figures 6.27 and 6.28. No time-averaged CCl_4 concentrations occur above draft surface water PRG value (0.58 mg/L) within the PSA 5 area. As such, CCl_4 was not simulated for the closure configuration.

The bar charts on Figure 6.27 and Figure 6.28 show simulated closure-condition groundwater discharge concentrations for PCE and TCE. Simulated PCE concentrations were below draft surface water PRGs for the average of all sensitivity runs at discharge locations. However, simulated groundwater discharge concentrations for the high source concentration sensitivity simulation, were above draft surface water PRG at several locations. Simulated TCE concentrations, averaged from all runs, were greater than the draft surface water PRG (0.19 mg/L) along a section of the southern tributary of South Walnut Creek (Figure 6.28). Two main factors contributed to the high-simulated discharge concentrations. The inferred VOC source (an oil burn pit), located west-northwest of the Mound trench source, causes the higher discharge concentrations. The Arapahoe Sandstone subcrops immediately west of the Mound trench source and the modeled oil burn pit source and may preferentially direct VOCs to south Walnut Creek.

Mass flux from the transport model indicated the simulated dominant loss mechanisms for VOCs were ET and biodegradation (Figure 6.29 and 6.30). Biodegradation was the more important mass flux loss mechanism for the parent, PCE, which is introduced as a constant concentration at the source. The TCE daughter, produced through PCE degradation, occurred down-gradient from the source nearer discharge areas where ET and loss to streams are more significant loss mechanisms.

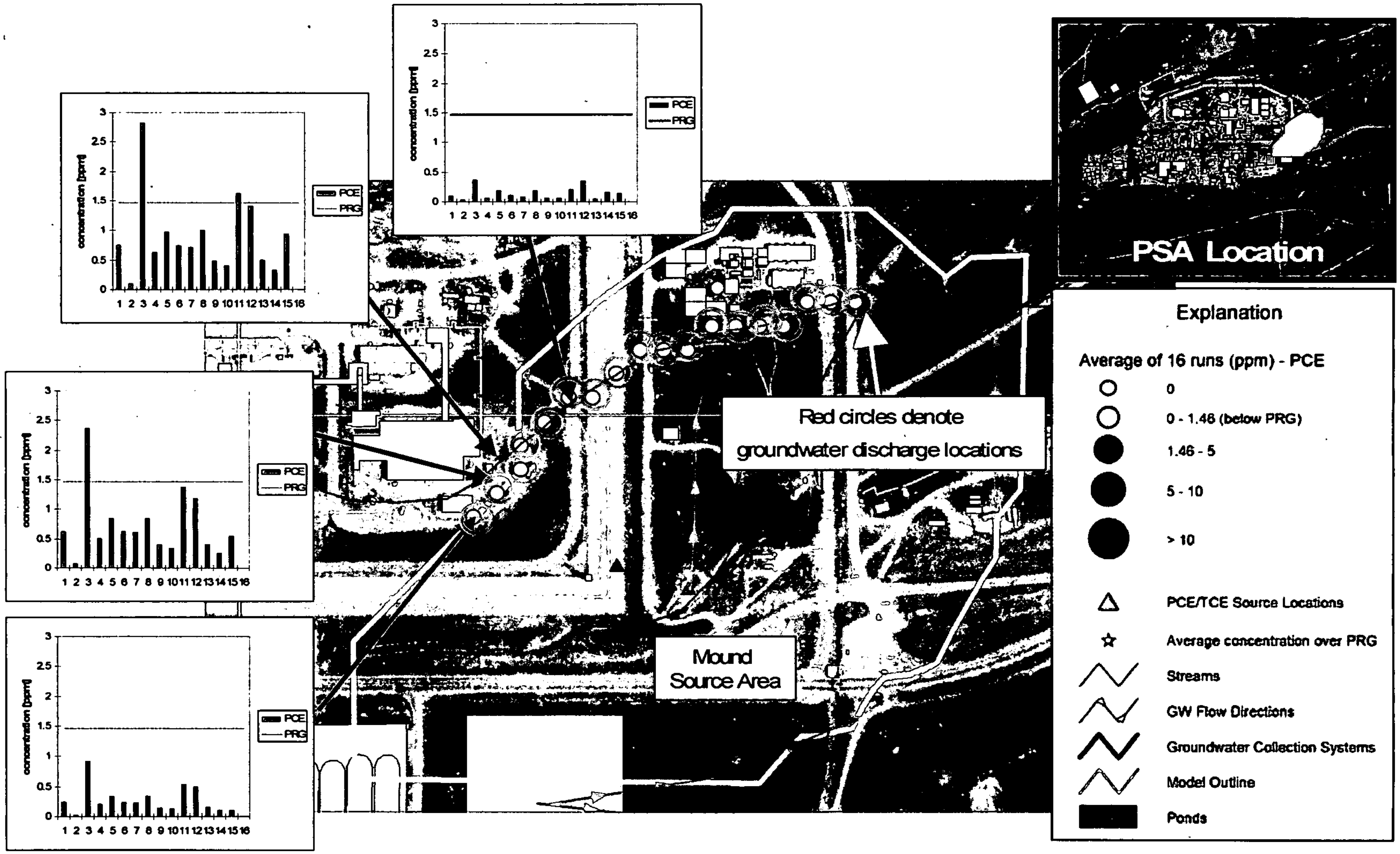

Figure 6.27. PSA 5 - Simulated PCE groundwater concentrations at discharge cells. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

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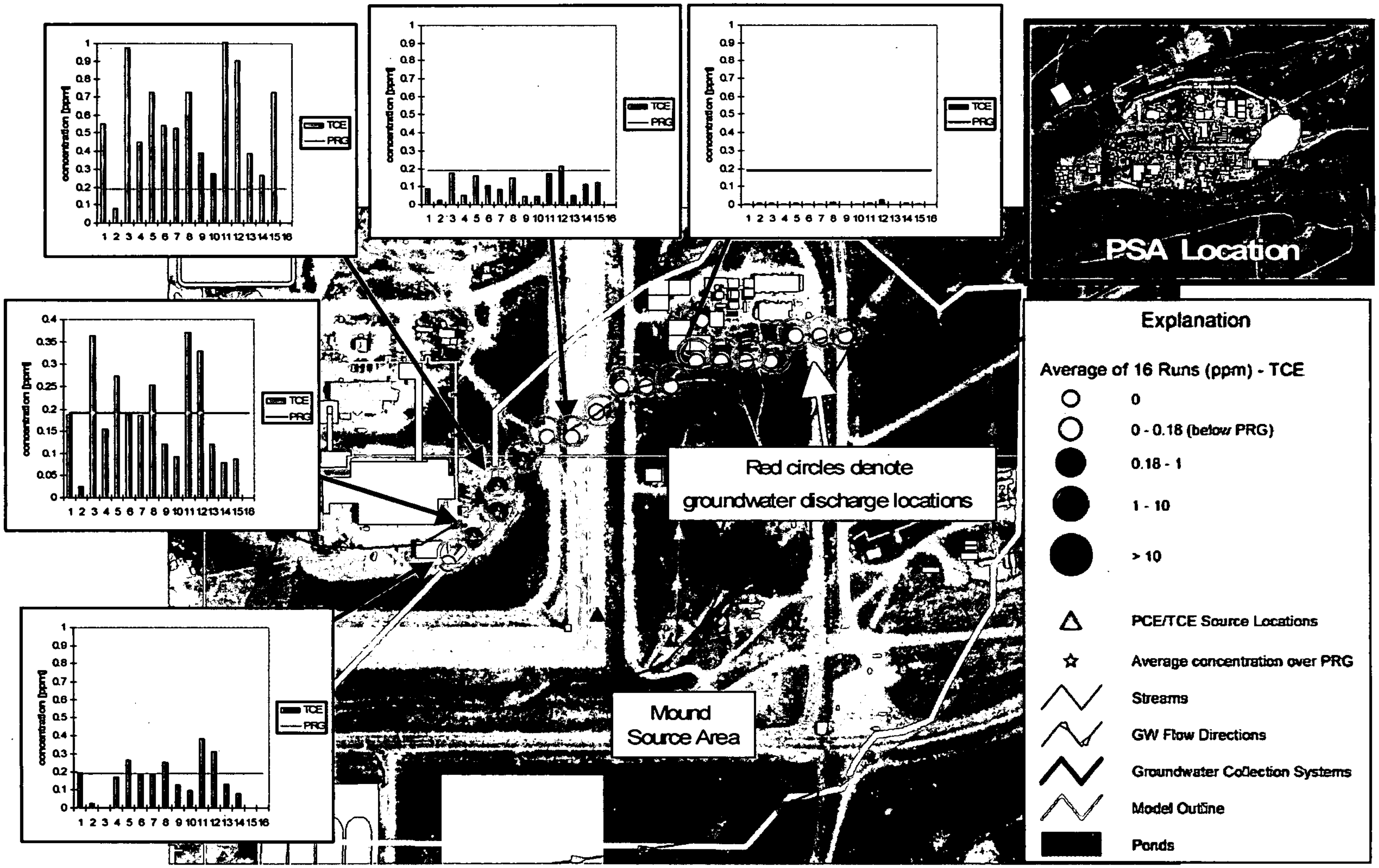

Figure 6.28. PSA 5 - Simulated TCE groundwater concentrations at discharge cells. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

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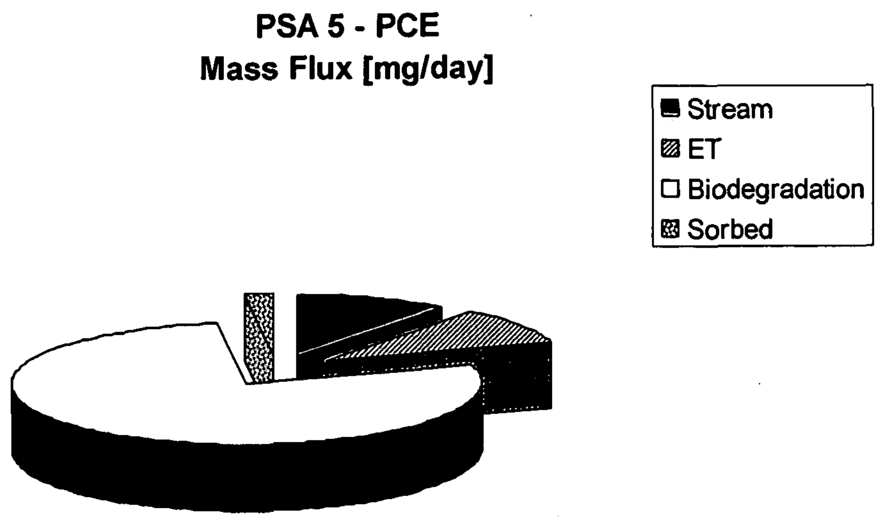

Figure 6.29. PSA 5 - Steady-state mass flux for PCE.

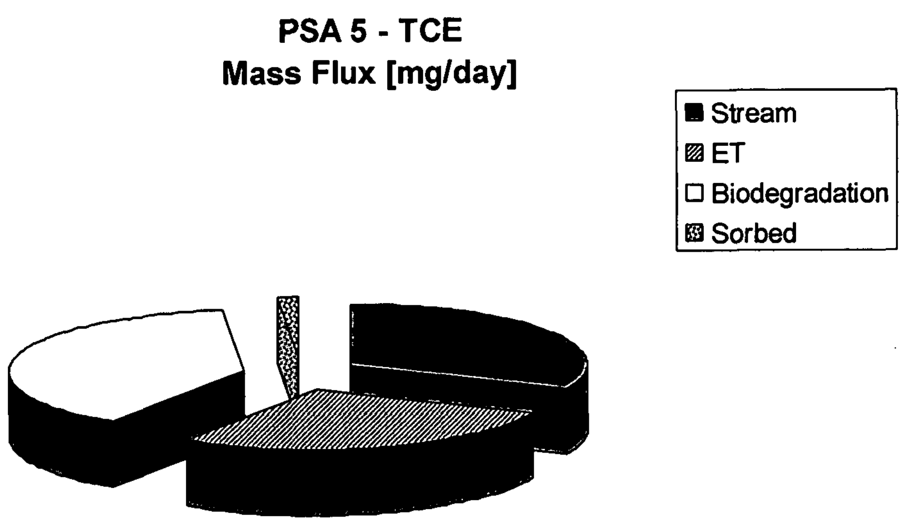

Figure 6.30. PSA 5 - Steady-state mass flux for TCE.

6.2.1.5 PSA 9 (881 Hillside Area)

The PSA 9 model area is located on the southern slope of the IA, southeast of the Building 881 area (Figure 6.1). PSA 9 occurs immediately north of the 881 Hillside Groundwater Collection System shown on Figure 6.31.

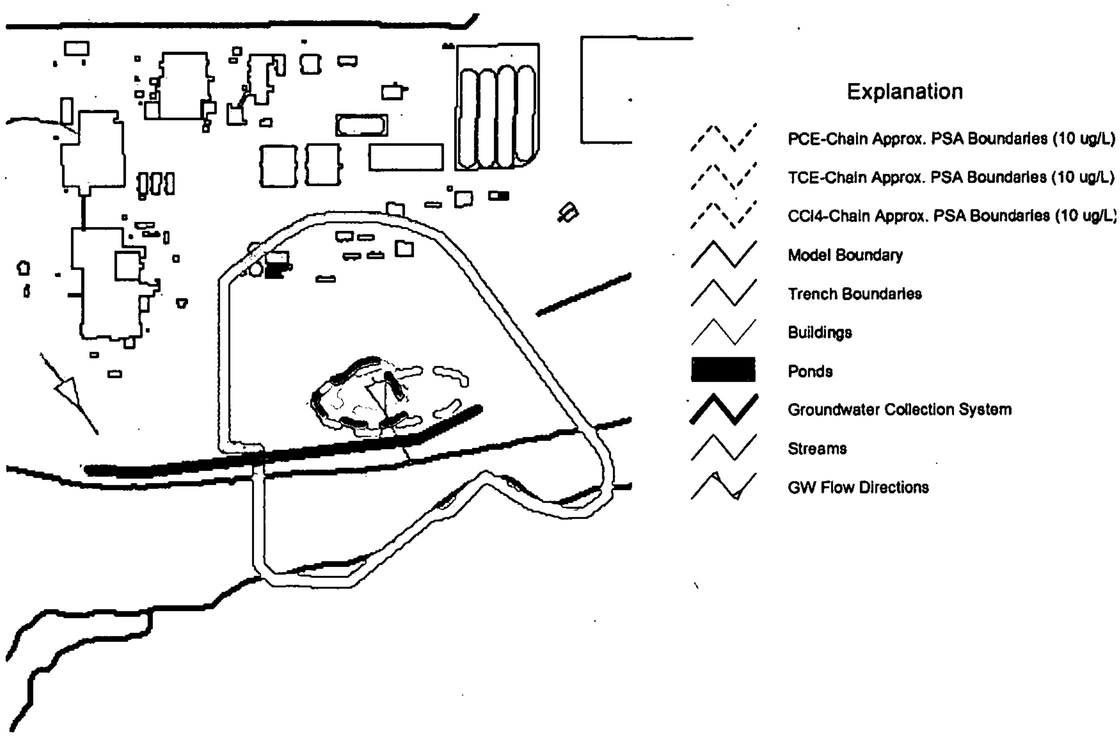

Figure 6.31. PSA 9 - Model area and PSA.

6.2.1.5.1 Groundwater Flow Model Results

Constant head boundaries for PSA 9 were placed along the northern and western up-gradient boundaries to simulate lateral inflow of groundwater. No-flow boundaries were specified along the hillslopes, parallel to groundwater flow. Constant heads were also assigned along Woman Creek at the southern boundary to simulate groundwater discharge to the stream area.

Simulated water balance results indicated that groundwater discharged through ET and to Woman Creek. Only a small amount discharged to the 881 Hillside Groundwater Collection System, which is consistent with available discharge information. Simulated hydraulic heads compare well with observed groundwater water levels in the area (Figure 6.32).

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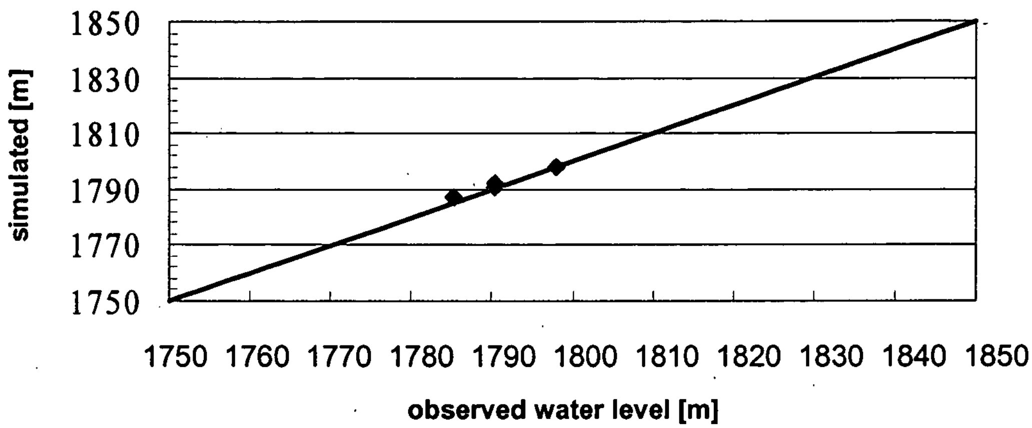

Figure 6.32. PSA 9 - Simulated versus average observed annual groundwater levels (meters above msl).

6.2.1.5.2 Simulated Groundwater VOC Sources

One Priority 2 release was documented within the PSA 9 area. HRR information indicates this was the "West Scrap Metal Storage Area" (HRR Reference No. 180 through 185, Appendix A). The release, discovered in 1968, included PCE, TCE, and CCl_4-chain contaminants; as well as unknown volumes of solvents, oil-grease, and nitrates.

6.2.1.5.3 Particle Tracking Results – Historical Conditions

Particles were introduced into the model at the inferred VOC source area and allowed to travel for 30 years (Figure 6.33). Particles were entered into the upper weathered bedrock because the thin overlying unconsolidated material in this PSA remains unsaturated most of the year.

Particle tracking results suggested that assumed source locations, depths, and release timing were reasonable. Results also indicated that calculated flow directions agreed well with the assumed PSA shape and extent (Figure 6.33). Particles traveled only short distances in this PSA because groundwater flows is restricted to the low conductivity weathered bedrock (claystone/siltstone). Arapahoe Sandstone is not present in this area. This is further supported by the low VOC concentrations collected at the 881 Hillside Groundwater Collection System, immediately down-gradient of PSA 9. VOC concentrations were consistently below RFCA Tier II Groundwater action levels which resulted in it being decommissioned in 2000 (Kaiser-Hill, 2003a).

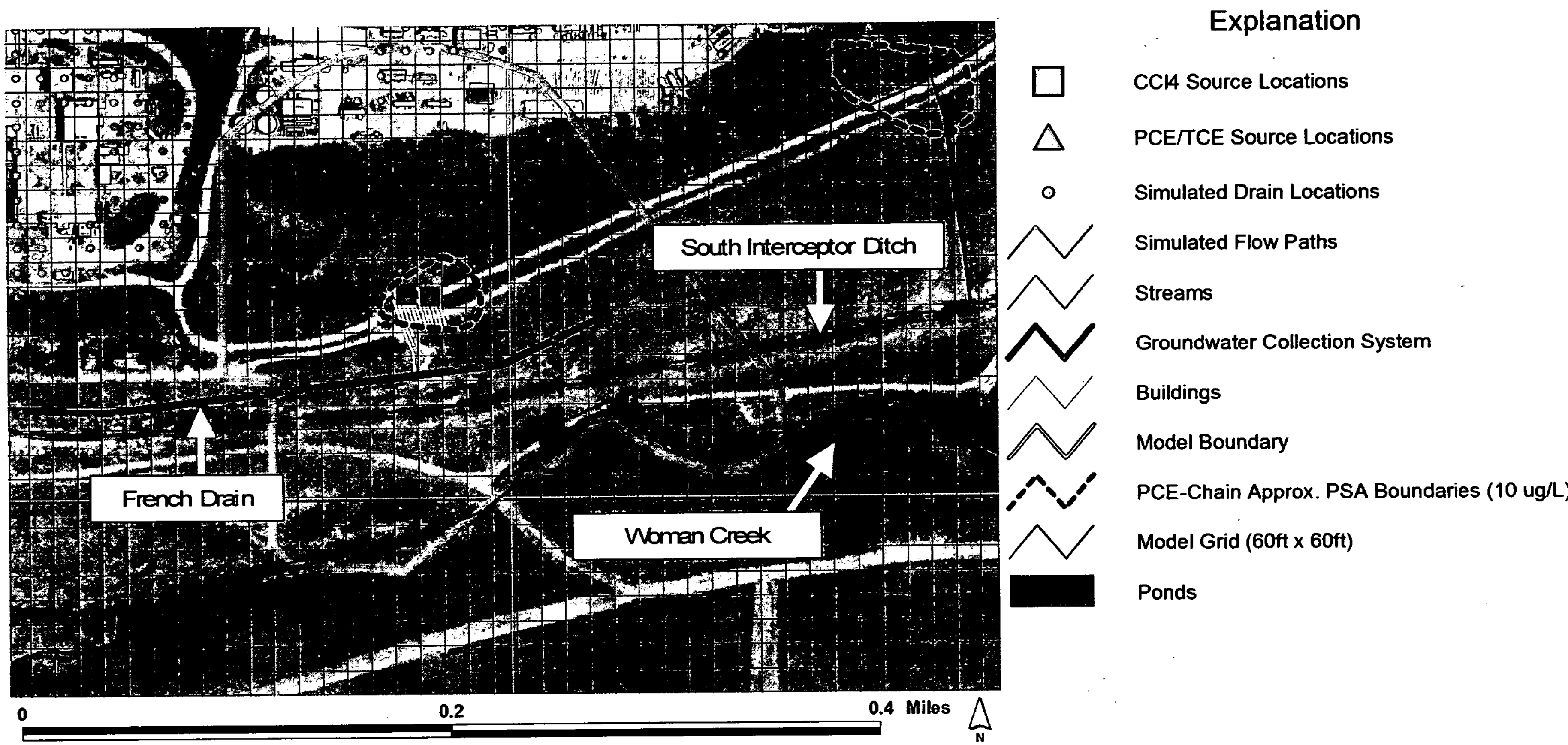

Figure 6.33. PSA 9 - Simulated flow paths (after 30 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

6.2.1.5.4 Transport Model Results – Historical Conditions

Within PSA 9, PCE, TCE, and CCl_4 were detected above the draft surface water PRG levels (1.4 mg/L, 0.19 mg/L, and 0.58 mg/L respectively). Estimated PSA boundaries for each VOC chain are shown on Figures B-1 through B-7 (Appendix B). Effective source concentrations were specified for PCE, TCE, and CCl_4 at the inferred VOC source location for PSA 9.

Results of sensitivity simulations conducted with the PSA 9 model showed that concentration distributions of parent VOCs, PCE, TCE, and CCl_4 were reproduced over the range of input parameter values considered. PSA 9 model residual concentration plots for TCE (i.e., log of time-averaged minus simulated concentrations), shown on Figures 6.34 and 6.35, indicated that, in areas down-gradient from the inferred VOC source, the highest concentrations (Figure 6.34) were produced with low degradation values, while the lowest concentrations (Figure 6.35) were produced when source concentrations were specified in the lower weathered bedrock. Sensitivity simulations of PCE and CCl_4 showed results similar to those obtained for TCE.

The PSA 9 model area was comparatively unique because simulated concentrations remained largely insensitive to changes in parameter values, as represented on Figure 6.34 (highest simulated concentrations) and Figure 6.35 (lowest simulated concentrations). In these figures, only the three northeastern observation points were affected by parameter changes. These zero observed concentration points produced higher model concentrations in the low degradation case, and zero concentrations in the case where the sources were introduced into the lowest layer of weathered bedrock. The insensitivity of the model to changes in parameter values can be mainly attributed to the low hydraulic conductivity of the weathered bedrock/siltstone/claystone in the area, which results in longer residence times and increased potential for degradation.

The observed concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain; chloroform and methylene chloride for the CCl_4 degradation chain) was bracketed by the various sensitivity runs, with high concentrations (producing high daughter products) and low degradation (producing low daughter products) cases for the PCE degradation chain. The results are shown on Figure D-7 and Figure D-8 of Appendix D.

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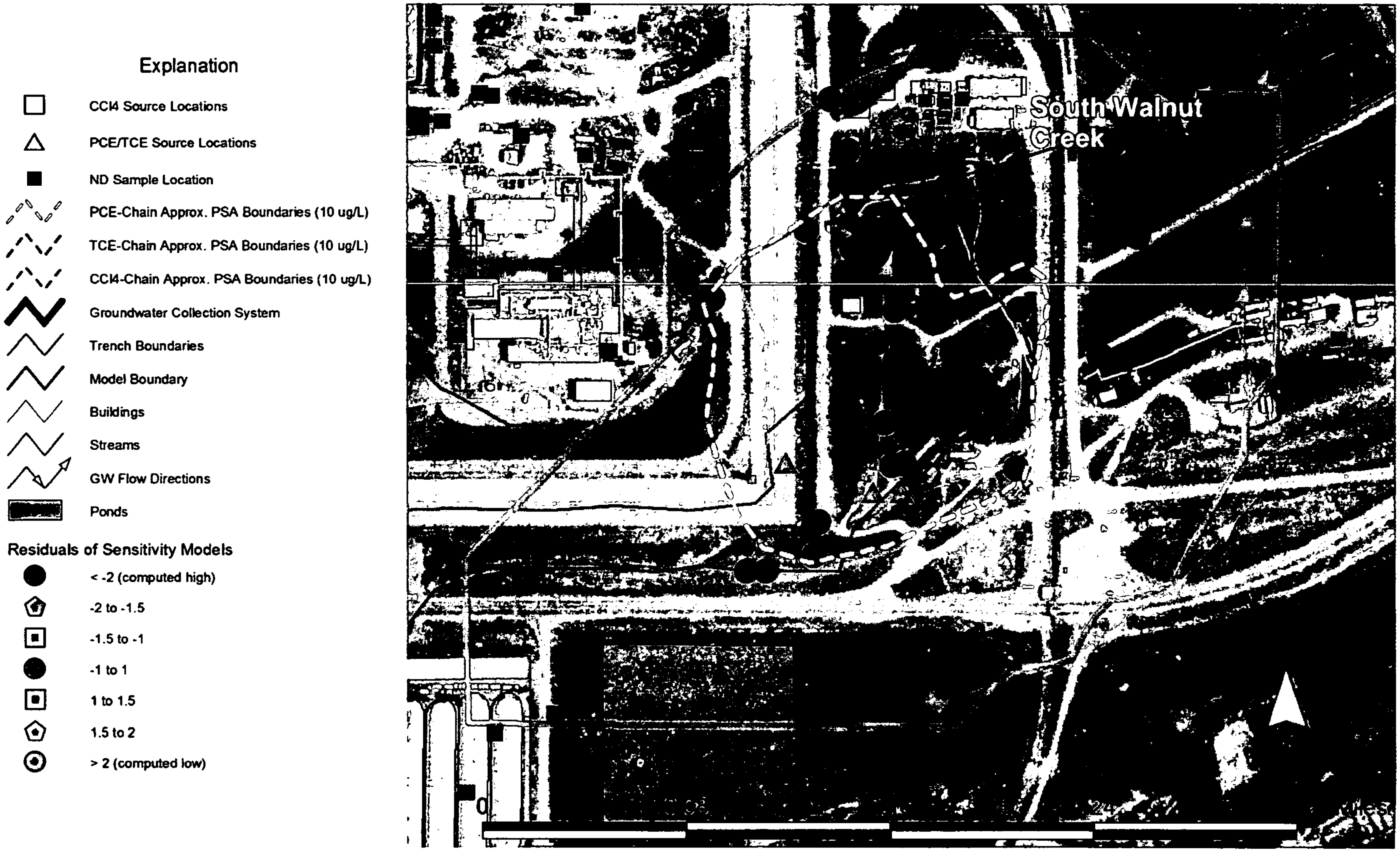

Figure 6.25. PSA 5 – Log residual concentrations. High predicted concentration (TCE) sensitivity run (high hydraulic conductivity).

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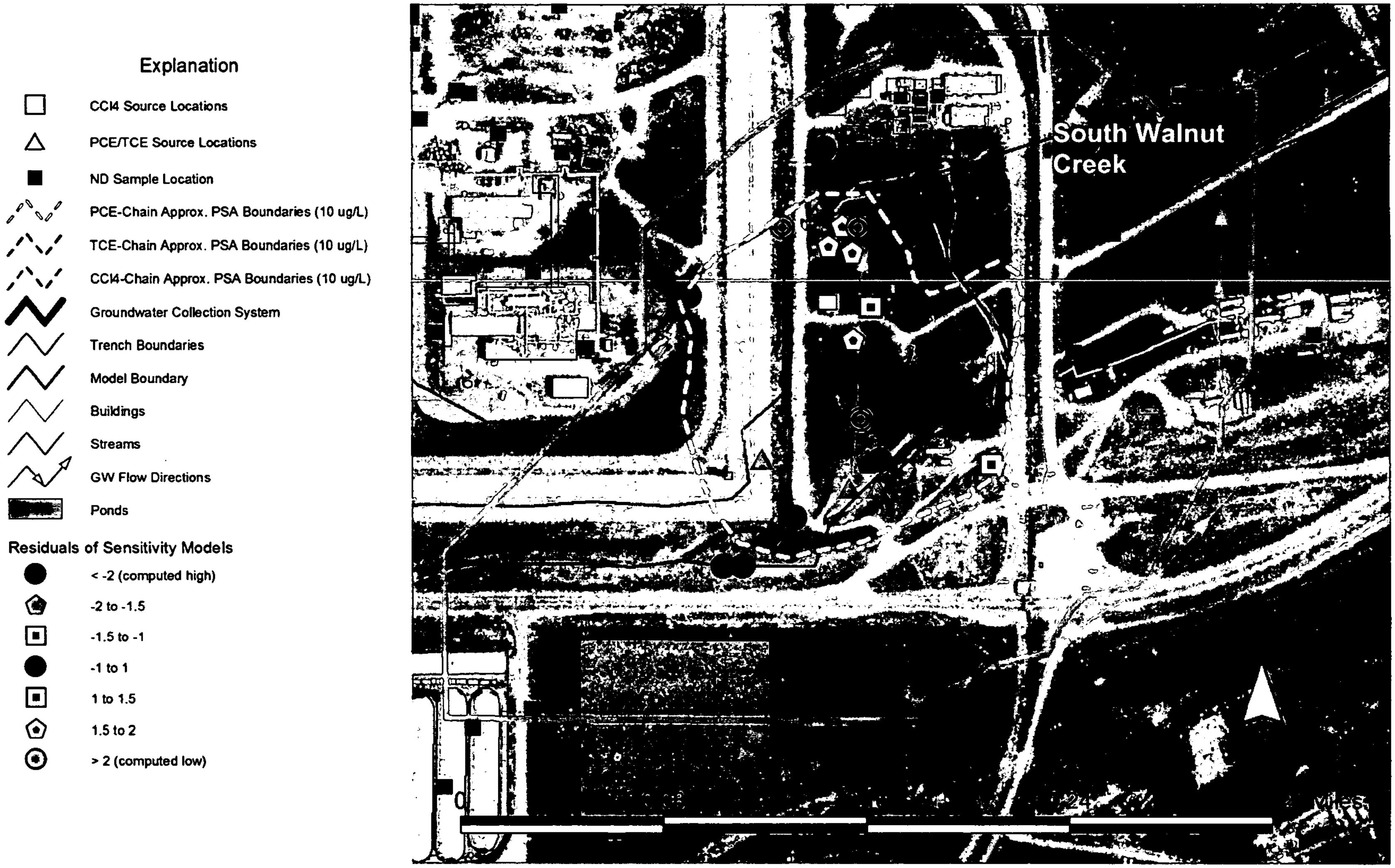

Figure 6.26. PSA 5 – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (low hydraulic conductivity).

extent along South Walnut Creek to the north and northwest. Steady-state conditions took at least 60 years to develop at all stream locations for this PSA. The average simulated groundwater concentration for each of the model runs at integrated flow groundwater discharge areas for PCE and TCE are shown on Figures 6.27 and 6.28. No time-averaged CCl_4 concentrations occur above draft surface water PRG value (0.58 mg/L) within the PSA 5 area. As such, CCl_4 was not simulated for the closure configuration.

The bar charts on Figure 6.27 and Figure 6.28 show simulated closure-condition groundwater discharge concentrations for PCE and TCE. Simulated PCE concentrations were below draft surface water PRGs for the average of all sensitivity runs at discharge locations. However, simulated groundwater discharge concentrations for the high source concentration sensitivity simulation, were above draft surface water PRG at several locations. Simulated TCE concentrations, averaged from all runs, were greater than the draft surface water PRG (0.19 mg/L) along a section of the southern tributary of South Walnut Creek (Figure 6.28). Two main factors contributed to the high-simulated discharge concentrations. The inferred VOC source (an oil burn pit), located west-northwest of the Mound trench source, causes the higher discharge concentrations. The Arapahoe Sandstone subcrops immediately west of the Mound trench source and the modeled oil burn pit source and may preferentially direct VOCs to south Walnut Creek.

Mass flux from the transport model indicated the simulated dominant loss mechanisms for VOCs were ET and biodegradation (Figure 6.29 and 6.30). Biodegradation was the more important mass flux loss mechanism for the parent, PCE, which is introduced as a constant concentration at the source. The TCE daughter, produced through PCE degradation, occurred down-gradient from the source nearer discharge areas where ET and loss to streams are more significant loss mechanisms.

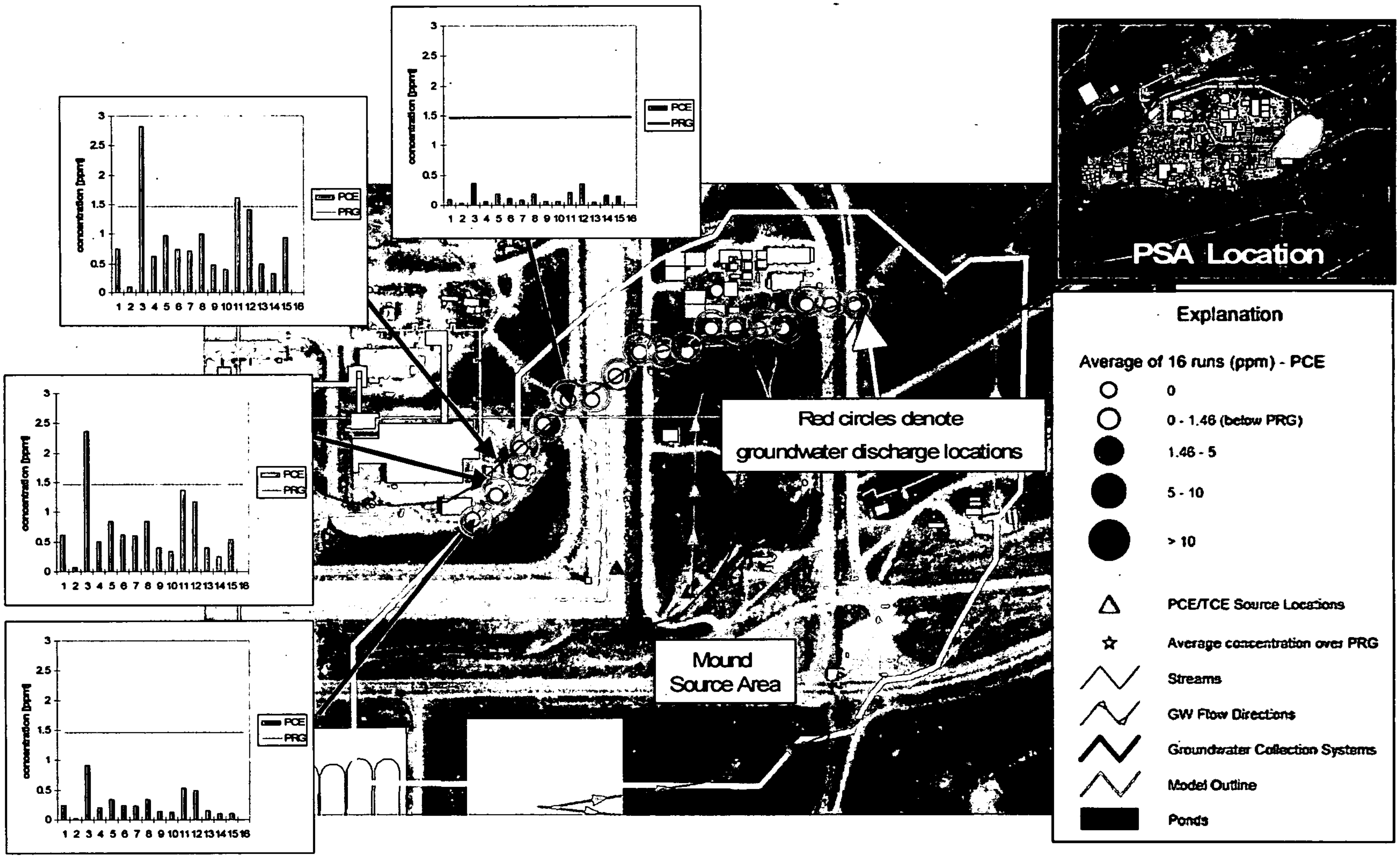

Figure 6.27. PSA 5 - Simulated PCE groundwater concentrations at discharge cells. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

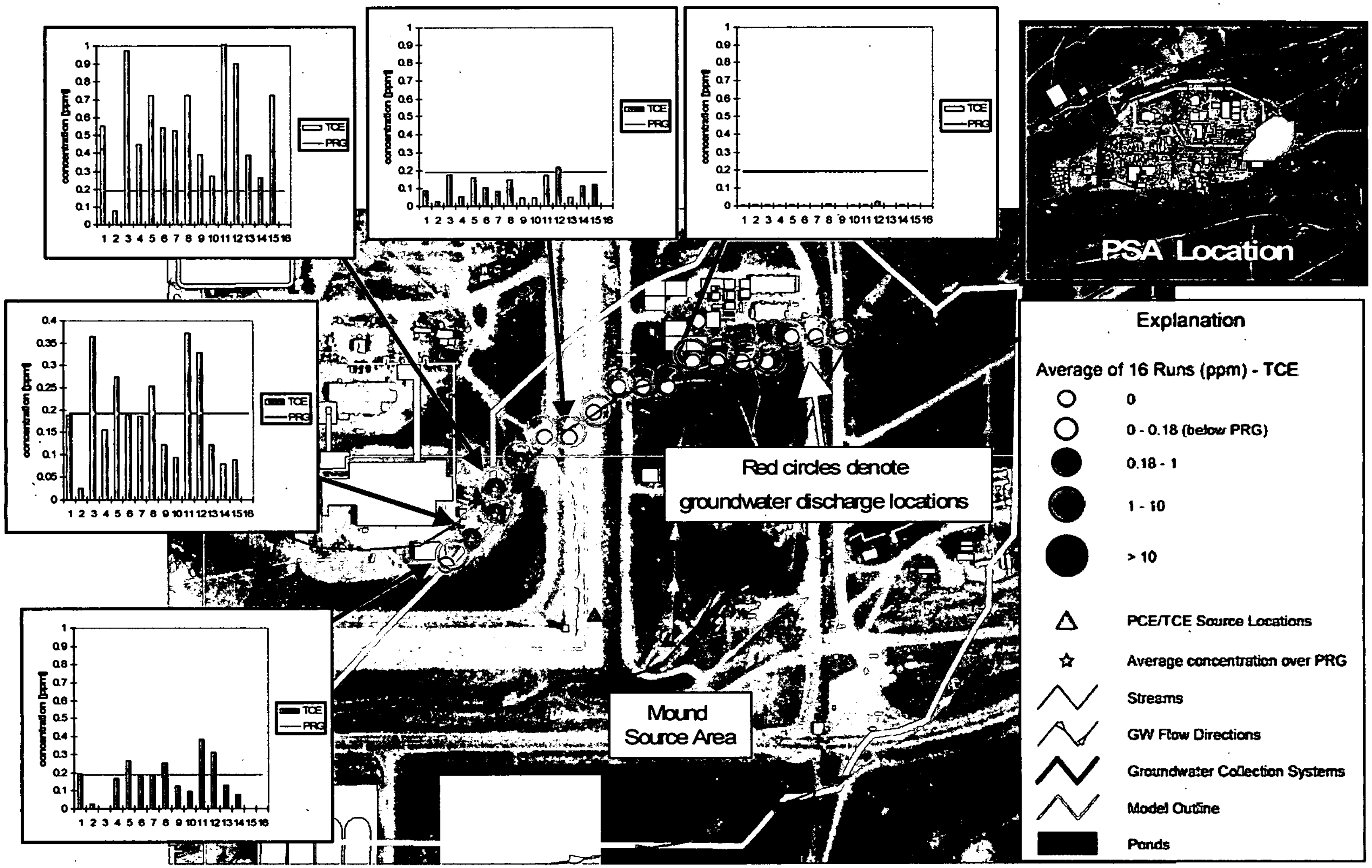

Figure 6.28. PSA 5 - Simulated TCE groundwater concentrations at discharge cells. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

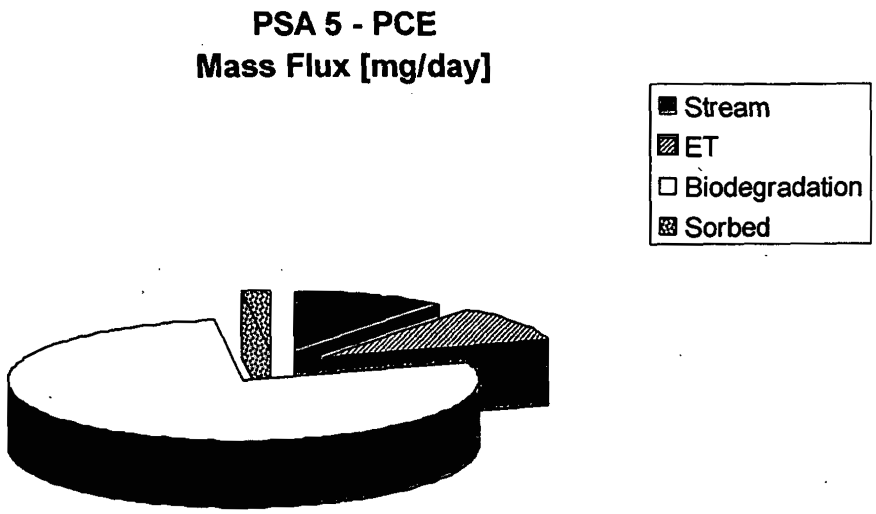

Figure 6.29. PSA 5 - Steady-state mass flux for PCE.

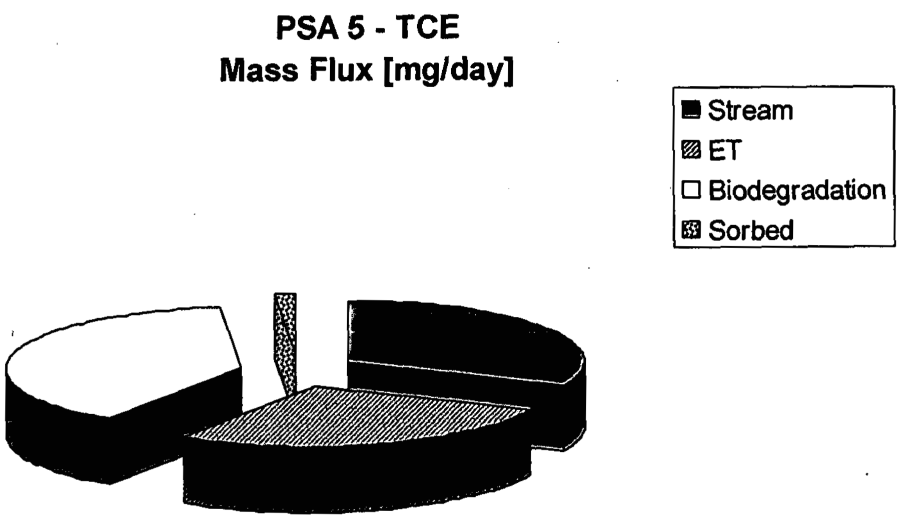

Figure 6.30. PSA 5 - Steady-state mass flux for TCE.

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6.2.1.5 *PSA 9 (881 Hillside Area)*

The PSA 9 model area is located on the southern slope of the IA, southeast of the Building 881 area (Figure 6.1). PSA 9 occurs immediately north of the 881 Hillside Groundwater Collection System shown on Figure 6.31.

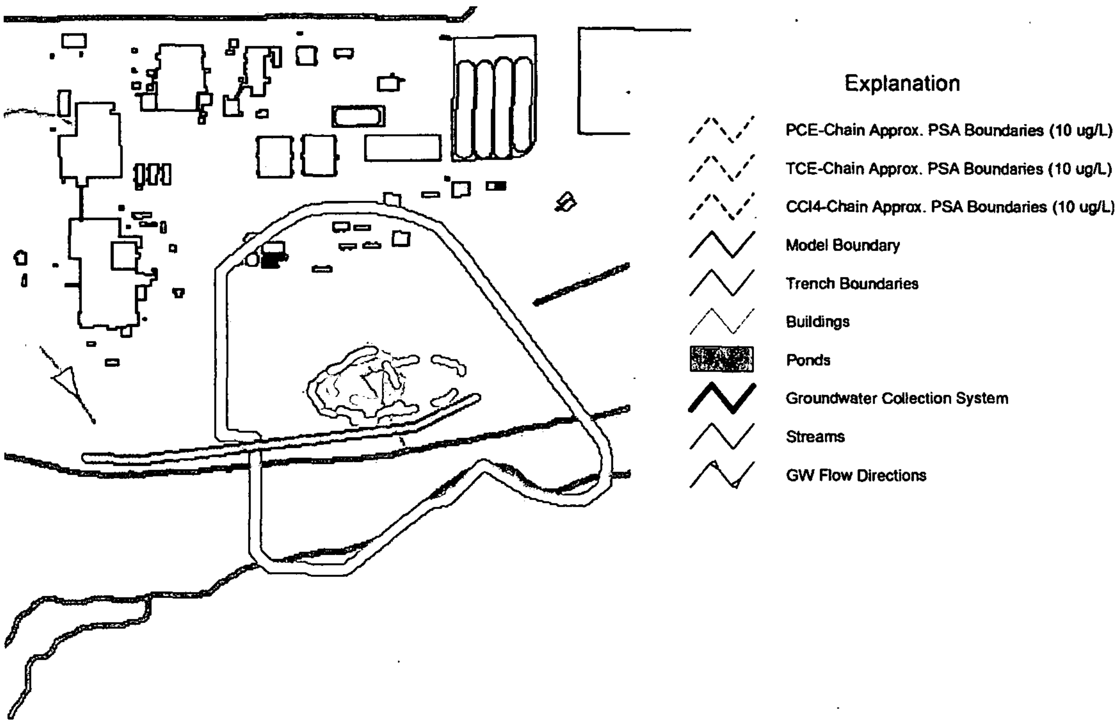

Figure 6.31. PSA 9 - Model area and PSA.

6.2.1.5.1 Groundwater Flow Model Results

Constant head boundaries for PSA 9 were placed along the northern and western up-gradient boundaries to simulate lateral inflow of groundwater. No-flow boundaries were specified along the hillslopes, parallel to groundwater flow. Constant heads were also assigned along Woman Creek at the southern boundary to simulate groundwater discharge to the stream area.

Simulated water balance results indicated that groundwater discharged through ET and to Woman Creek. Only a small amount discharged to the 881 Hillside Groundwater Collection System, which is consistent with available discharge information. Simulated hydraulic heads compare well with observed groundwater water levels in the area (Figure 6.32).

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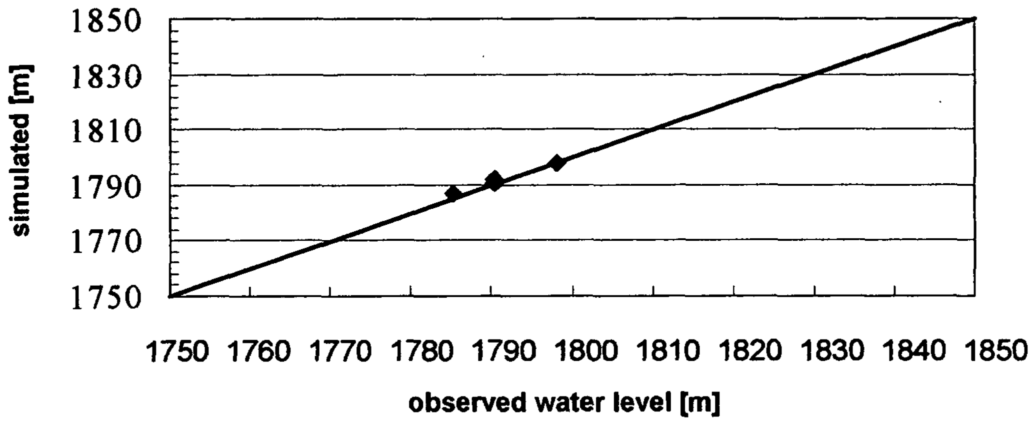

Figure 6.32. PSA 9 - Simulated versus average observed annual groundwater levels (meters above msl).

6.2.1.5.2 Simulated Groundwater VOC Sources

One Priority 2 release was documented within the PSA 9 area. HRR information indicates this was the "West Scrap Metal Storage Area" (HRR Reference No. 180 through 185, Appendix A). The release, discovered in 1968, included PCE, TCE, and CCl_4-chain contaminants; as well as unknown volumes of solvents, oil-grease, and nitrates.

6.2.1.5.3 Particle Tracking Results – Historical Conditions

Particles were introduced into the model at the inferred VOC source area and allowed to travel for 30 years (Figure 6.33). Particles were entered into the upper weathered bedrock because the thin overlying unconsolidated material in this PSA remains unsaturated most of the year.

Particle tracking results suggested that assumed source locations, depths, and release timing were reasonable. Results also indicated that calculated flow directions agreed well with the assumed PSA shape and extent (Figure 6.33). Particles traveled only short distances in this PSA because groundwater flows is restricted to the low conductivity weathered bedrock (claystone/siltstone). Arapahoe Sandstone is not present in this area. This is further supported by the low VOC concentrations collected at the 881 Hillside Groundwater Collection System, immediately down-gradient of PSA 9. VOC concentrations were consistently below RFCA Tier II Groundwater action levels which resulted in it being decommissioned in 2000 (Kaiser-Hill, 2003a).

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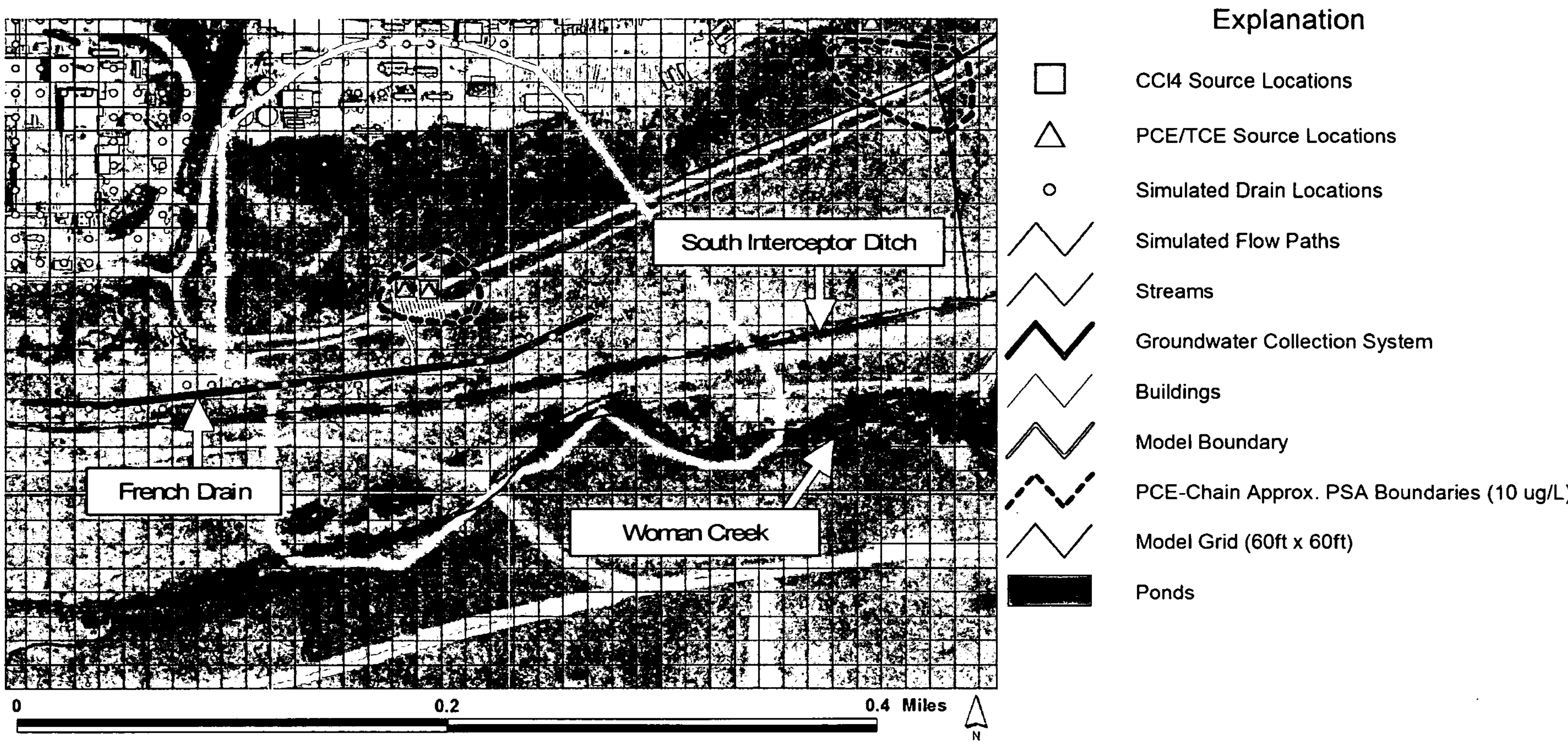

Figure 6.33. PSA 9 - Simulated flow paths (after 30 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

6.2.1.5.4 Transport Model Results – Historical Conditions

Within PSA 9, PCE, TCE, and CCl_4 were detected above the draft surface water PRG levels (1.4 mg/L, 0.19 mg/L, and 0.58 mg/L respectively). Estimated PSA boundaries for each VOC chain are shown on Figures B-1 through B-7 (Appendix B). Effective source concentrations were specified for PCE, TCE, and CCl_4 at the inferred VOC source location for PSA 9.

Results of sensitivity simulations conducted with the PSA 9 model showed that concentration distributions of parent VOCs, PCE, TCE, and CCl_4 were reproduced over the range of input parameter values considered. PSA 9 model residual concentration plots for TCE (i.e., log of time-averaged minus simulated concentrations), shown on Figures 6.34 and 6.35, indicated that, in areas down-gradient from the inferred VOC source, the highest concentrations (Figure 6.34) were produced with low degradation values, while the lowest concentrations (Figure 6.35) were produced when source concentrations were specified in the lower weathered bedrock. Sensitivity simulations of PCE and CCl_4 showed results similar to those obtained for TCE.

The PSA 9 model area was comparatively unique because simulated concentrations remained largely insensitive to changes in parameter values, as represented on Figure 6.34 (highest simulated concentrations) and Figure 6.35 (lowest simulated concentrations). In these figures, only the three northeastern observation points were affected by parameter changes. These zero observed concentration points produced higher model concentrations in the low degradation case, and zero concentrations in the case where the sources were introduced into the lowest layer of weathered bedrock. The insensitivity of the model to changes in parameter values can be mainly attributed to the low hydraulic conductivity of the weathered bedrock/siltstone/claystone in the area, which results in longer residence times and increased potential for degradation.

The observed concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain; chloroform and methylene chloride for the CCl_4 degradation chain) was bracketed by the various sensitivity runs, with high concentrations (producing high daughter products) and low degradation (producing low daughter products) cases for the PCE degradation chain. The results are shown on Figure D-7 and Figure D-8 of Appendix D.

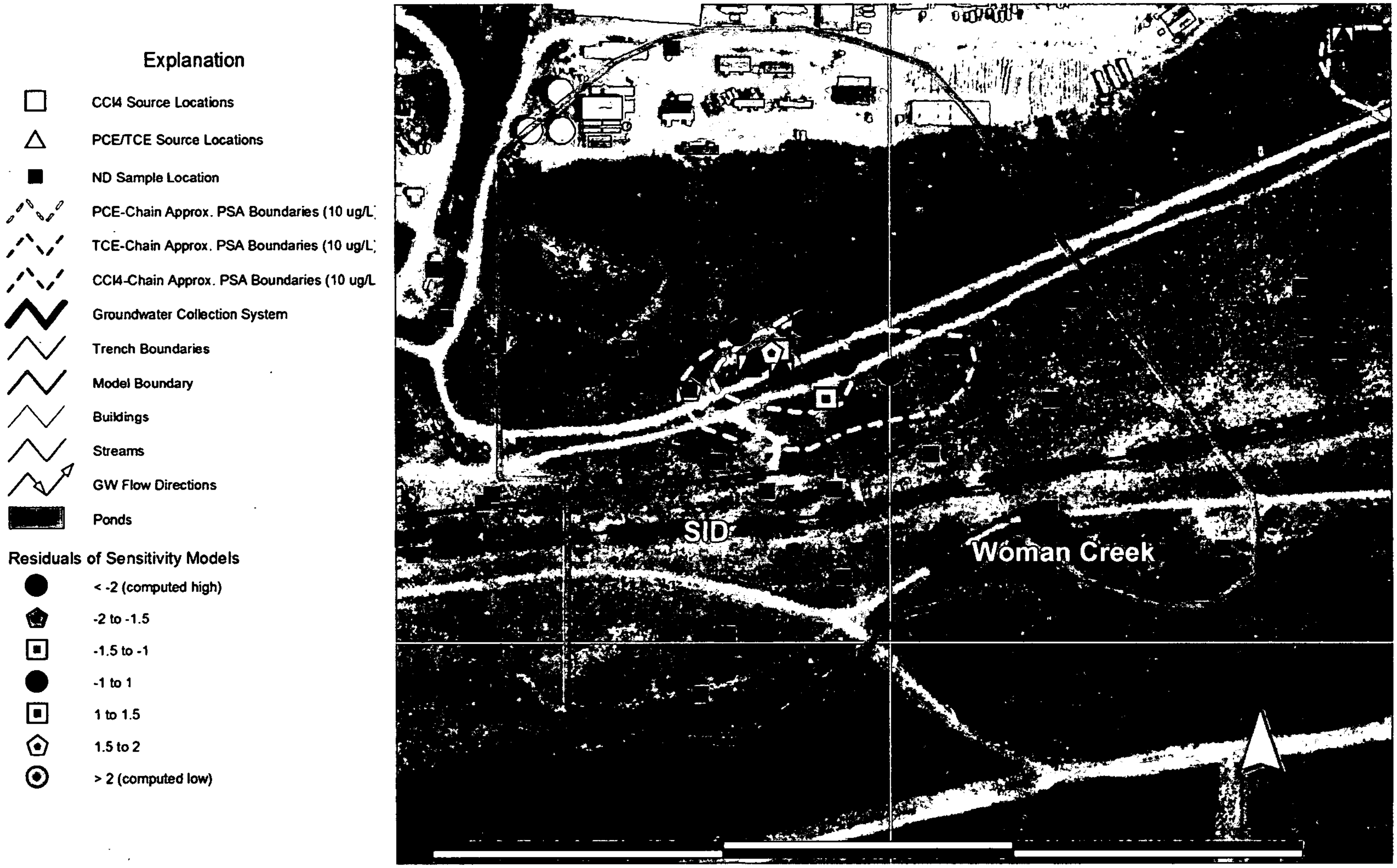

Figure 6.34. PSA 9 – Log residual concentrations. High predicted concentration (TCE) sensitivity run (low degradation).

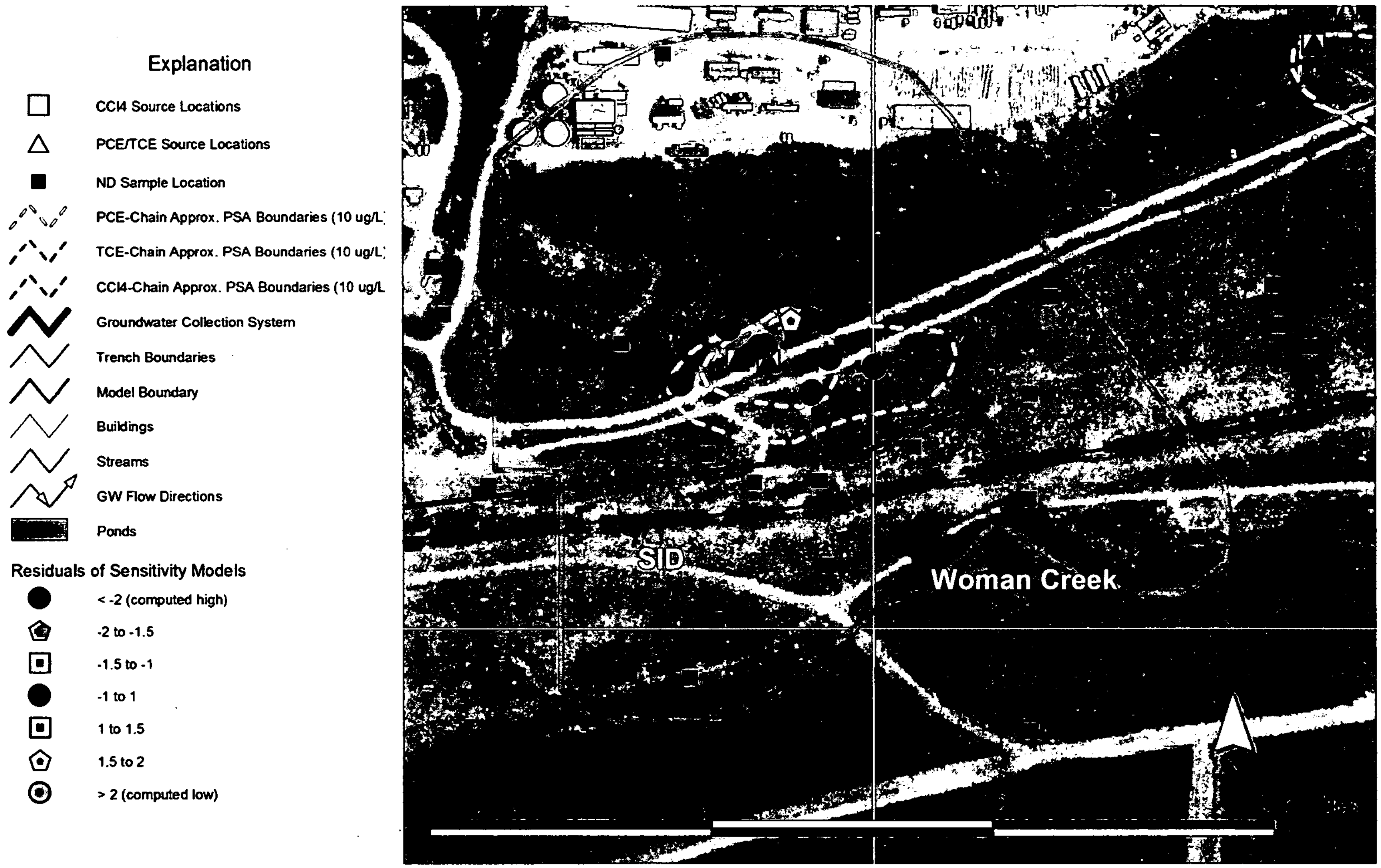

Figure 6.35. PSA 9 – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (contaminants introduced into lowest weathered bedrock layer).

6.2.1.5.5 Transport Model Results – Closure Configuration

In PSA 9, groundwater flows primarily within the weathered bedrock to the south towards the SID and Woman Creek for current conditions. Integrated flow modeling of the closure configuration showed that groundwater flow paths and velocities change little in the PSA 9 model area.

A total of 16 transport simulations were run using the PSA 9 model. All runs were simulated for 100 years to establish steady long-term concentrations with time at the southern PSA extent, along Woman Creek. Simulated groundwater concentrations for the 16 sensitivity simulations at selected groundwater discharge locations along Woman Creek are shown on Figure 6.36 and Figure 6.37.

The bar charts on Figure 6.36 show discharge locations impacted by TCE. Simulated concentrations at these locations ranged from non-detect (zero) to a approximately 0.01 mg/L down-gradient of the inferred VOC source. The PCE/TCE chain was not predicted to impact groundwater above draft surface water PRG levels at any potential discharge location.

The bar charts on Figure 6.37 show discharge locations that have the most potential to be impacted by CCl_4. Simulated concentrations at these locations were zero down-gradient of the inferred VOC source. The CCl_4 chain was not predicted to impact groundwater above draft surface water PRG levels at any potential discharge location.

Results from the 16 sensitivity models indicated that PCE/TCE and CCl_4 degradation chains have a low sensitivity to changes in parameter values such as; source release location, dispersivity, sorption, porosity, source concentration, degradation rates, and hydraulic conductivity. Mass flux from the transport model indicated that the simulated dominant loss mechanism for VOCs was biodegradation (as shown on Figures 6.38 and 6.39).

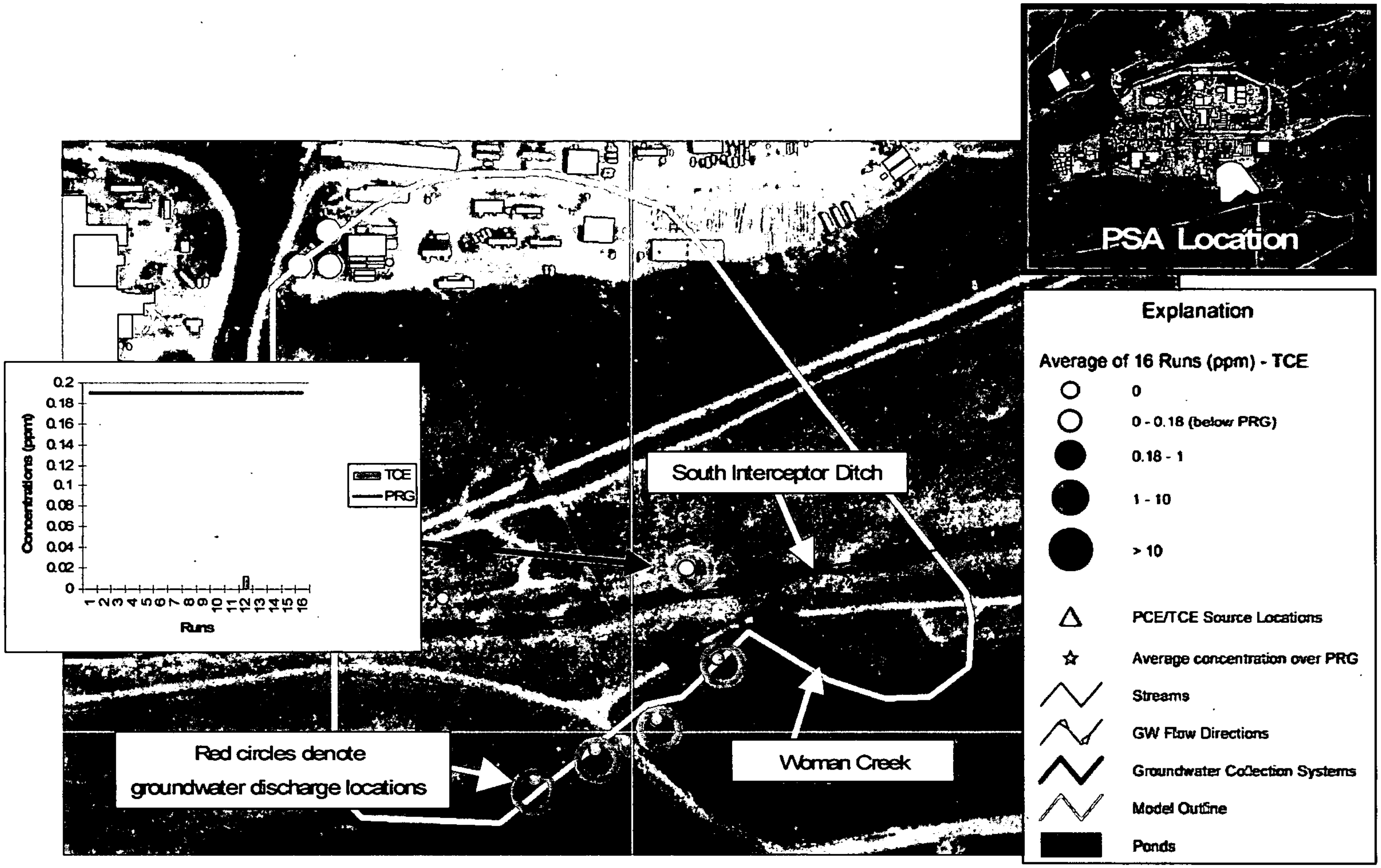

Figure 6.36. PSA 9 - Simulated TCE groundwater concentrations at potential discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

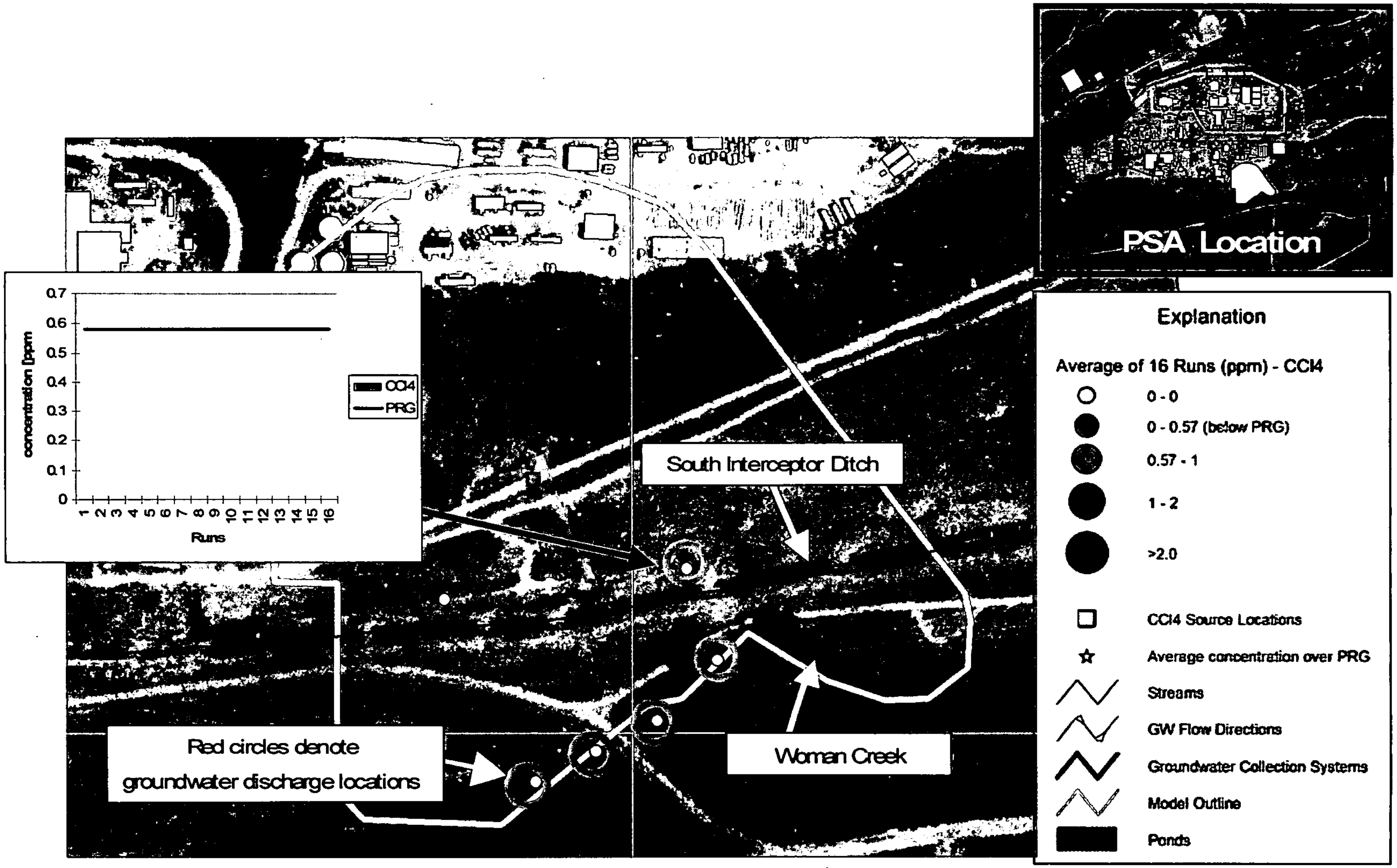

Figure 6.37. PSA 9 - Simulated CCl_4 groundwater concentrations at potential discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

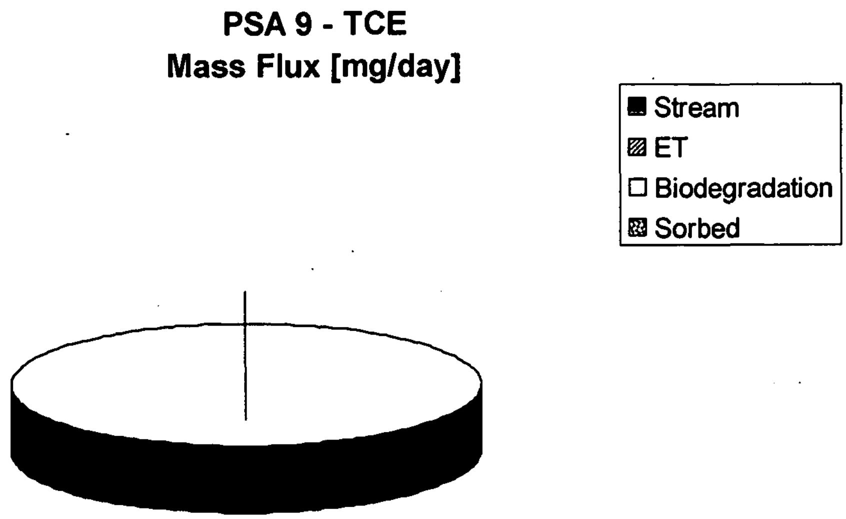

Figure 6.38. PSA 9 - Simulated steady-state mass flux for TCE.

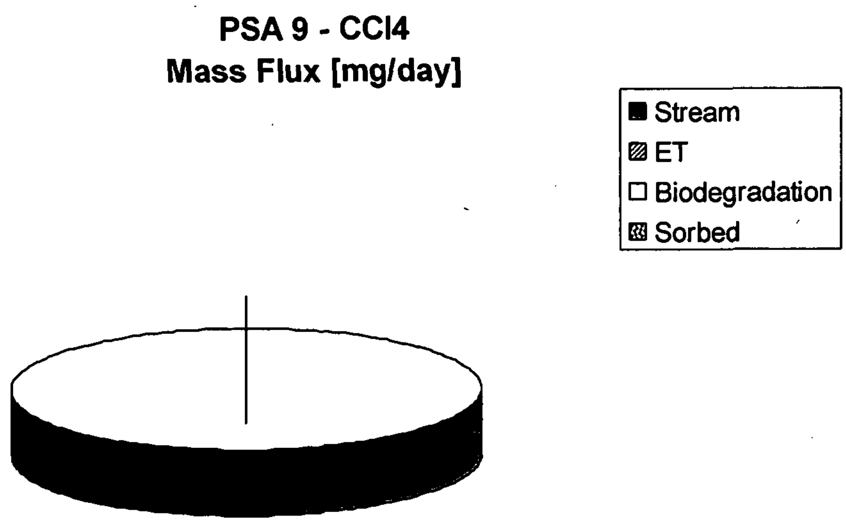

Figure 6.39. PSA 9 - Simulated steady-state mass flux for CCl_4.

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6.2.1.6 PSA 10 (Building 444 Area)

The PSA 10 model area is defined on Figure 6.1 and Figure 6.40. Only the PCE VOC-chain was simulated in this area.

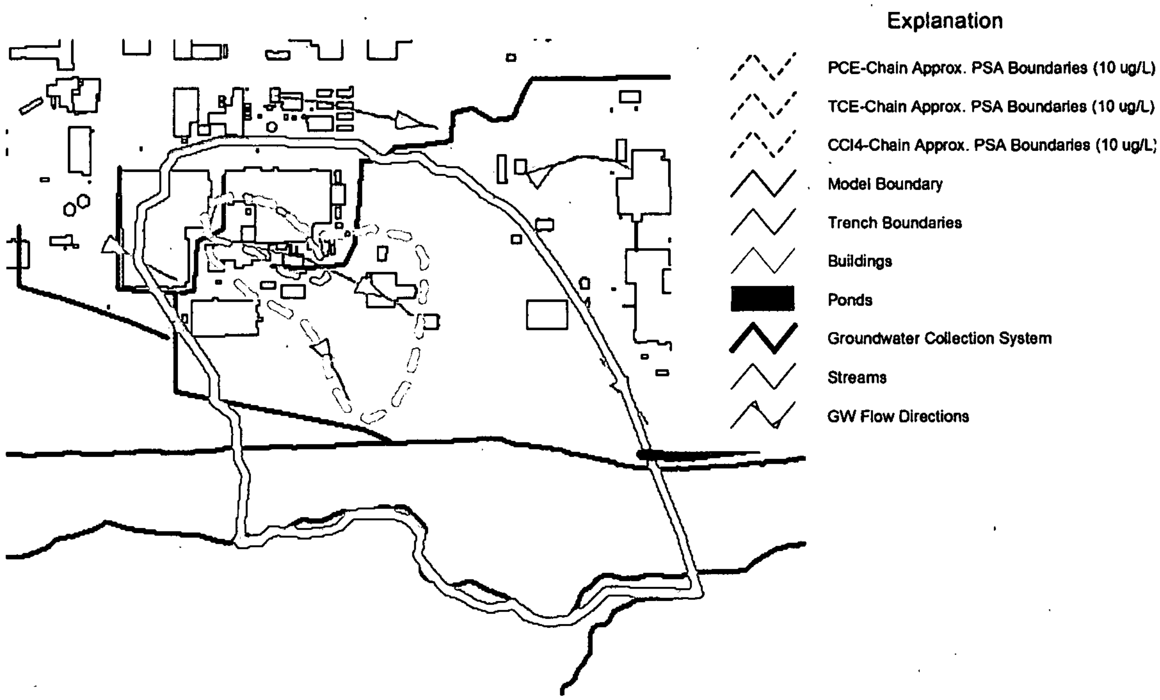

Figure 6.40. PSA 10 - Model area and PSA.

6.2.1.6.1 Groundwater Flow Model Results

Constant head boundaries for PSA 10 were placed along the northern and western up-gradient boundaries, where groundwater flows into the model. They were also specified along the eastern and southern down-gradient boundary (along Woman Creek) where groundwater flow discharges. Simulated water balance results indicated that discharge occurred primarily as ET and to a lesser extent, baseflow and drain discharge. Simulated heads compared well with observed groundwater levels in the model area, with residuals ranging from 1 to 2 meters (Figure 6.41).

6.2.1.6.2 Simulated Groundwater VOC Sources

Three Priority 1 releases and three Priority 2 releases were identified in PSA 10 for PCE and TCE. The Priority 1 releases were described as "B44/B453 Drum Storage Area", "B444", and "B447" (HRR Reference No. 10, Appendix A). HRR information indicated these releases were discovered between 1951 and 1957, and PCE and TCA-chain contaminants; as well as unknown volumes of solvents,

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oil-grease, and nitrates were found. The Priority 2 releases were described as "South Loading Dock", "Radioactive Site", and "Uranium Chip Roaster" (HRR Reference No. 88, and 90-93, Appendix A). The HRR also indicated that these releases were discovered between 1953 and 1956 (approximately) and included TCE and CCl_4- chain contaminants and unknown volumes of solvents and oil-grease.

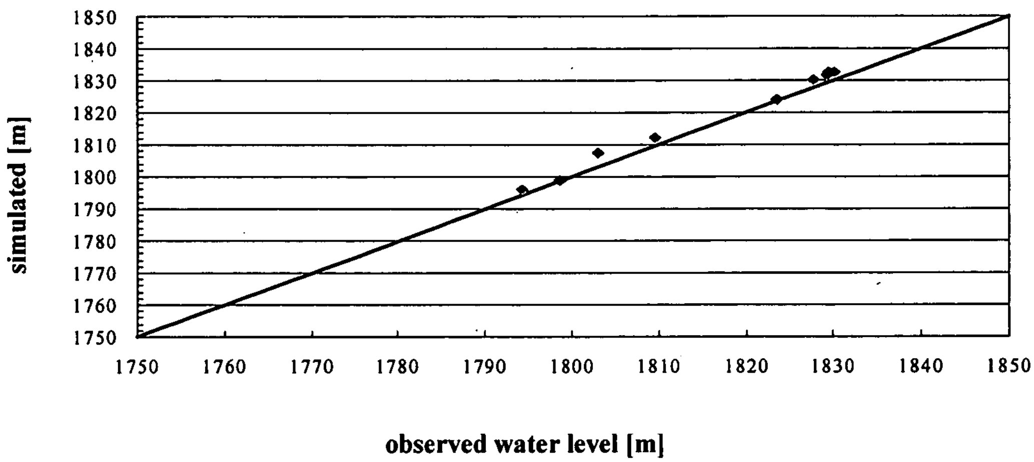

Figure 6.41. PSA 10 - Simulated versus average observed annual groundwater levels (meters above msl).

6.2.1.6.3 Particle Tracking Results – Historical Conditions

Particles introduced into the model at these locations were allowed to travel for 50 years. Source particles were entered into the lower unconsolidated material because it is relatively thick and remained saturated in the steady-state flow model.

Particle tracking results (shown on Figure 6.42) agreed well with the assumed PSA 10 extent, and pathways did not intersect either the SID or Woman Creek. Results showed that flow directions were generally south to southeast. Subsurface drains (shown in green) affected the pathways only slightly. Pathways were affected more by unsaturated unconsolidated material areas along the hillslope, which caused changes in the velocity, and by the pathway at the southern extent. Time-averaged well VOC concentrations in the southern PSA area are probably due to dispersion, not advective transport.

6.2.1.6.4 Transport Model Results – Historical Conditions

TCE was detected above the draft surface water PRG level (0.19 mg/L) within the PSA 10 area. PCE was detected at a maximum average historical concentration of 0.25 mg/L, which was below the draft surface water PRG level

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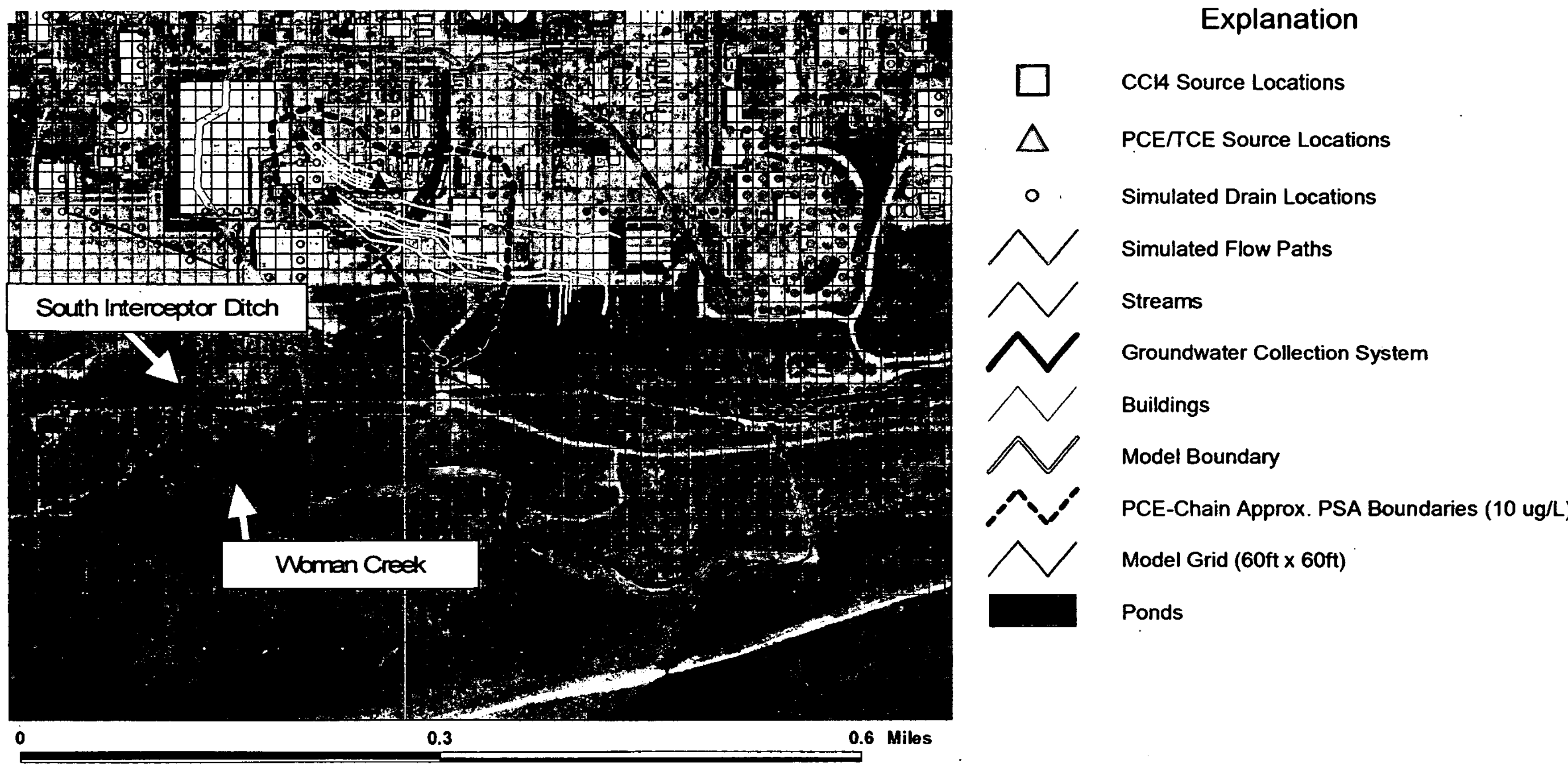

Figure 6.42. PSA 10 - Simulated flow paths (after 50 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

of 1.46 mg/L. CCl_4 was not detected above 10 ug/L within the PSA 10 area. Estimated PSA boundaries for the PCE chain are shown on Figures B-1 through B-4 (in Appendix B).

Plots showing the log residual concentrations for TCE (i.e., log of observed minus simulated concentrations) are shown on Figures 6.43 and 6.44. Results of sensitivity simulations indicated that the highest down-gradient concentrations (Figure 6.43) were produced with low degradation values and the lowest down-gradient concentrations (Figure 6.44) were produced with high degradation values. The two southern-most observation points are located across the SID and are insensitive to the high and low concentration model runs. Emphasis was placed on reproducing down-gradient wells, as near-source well concentrations may not reflect well-mixed groundwater concentrations.

Down-gradient concentrations (close to Woman Creek and the SID) were only slightly sensitive to parameter values changes in the model, while sample locations south of Woman Creek had no response (Figure 6.43 and Figure 6.44). A long groundwater flow path from the up-gradient source area allowed for longer residence times and increased potential for degradation. Additionally, as groundwater nears the streams, VOC loss to ET increases. In general, model simulations indicated that groundwater travels within the upper, unconsolidated material in the PSA 10 area.

The PSA 10 model performed well. Sensitivity simulations bracketed the observed average historical concentrations of parent and daughter products and performed as expected for each parameter change (based on descriptions in Table 6.3). The observed concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain) was bracketed by the various sensitivity runs with the high source concentration (producing high daughter products) and low degradation (producing low daughter products) cases for the PCE degradation chain are shown on Figure D-9 and Figure D-10 of Appendix D.

6.2.1.6.5 Transport Model Results – Closure Configuration

Results of the integrated flow modeling of the closure configuration showed that groundwater flow directions up-gradient of the SID in PSA 10 changed slightly. Under current conditions, flows from inferred VOC sources near Building 444 were directed southeastward, then southward along the hillslope towards the SID and Woman Creek. For the closure configuration, the integrated flow model simulated flow directions near the inferred source area in a more eastward direction than current conditions, but then is redirected southward toward the SID and Woman Creek. This change is due to notable modifications (i.e., removal of subsurface drains, buildings, and pavement) in the inferred source areas. Groundwater in the PSA 10 area flows in both the upper unconsolidated material and weathered bedrock layers.

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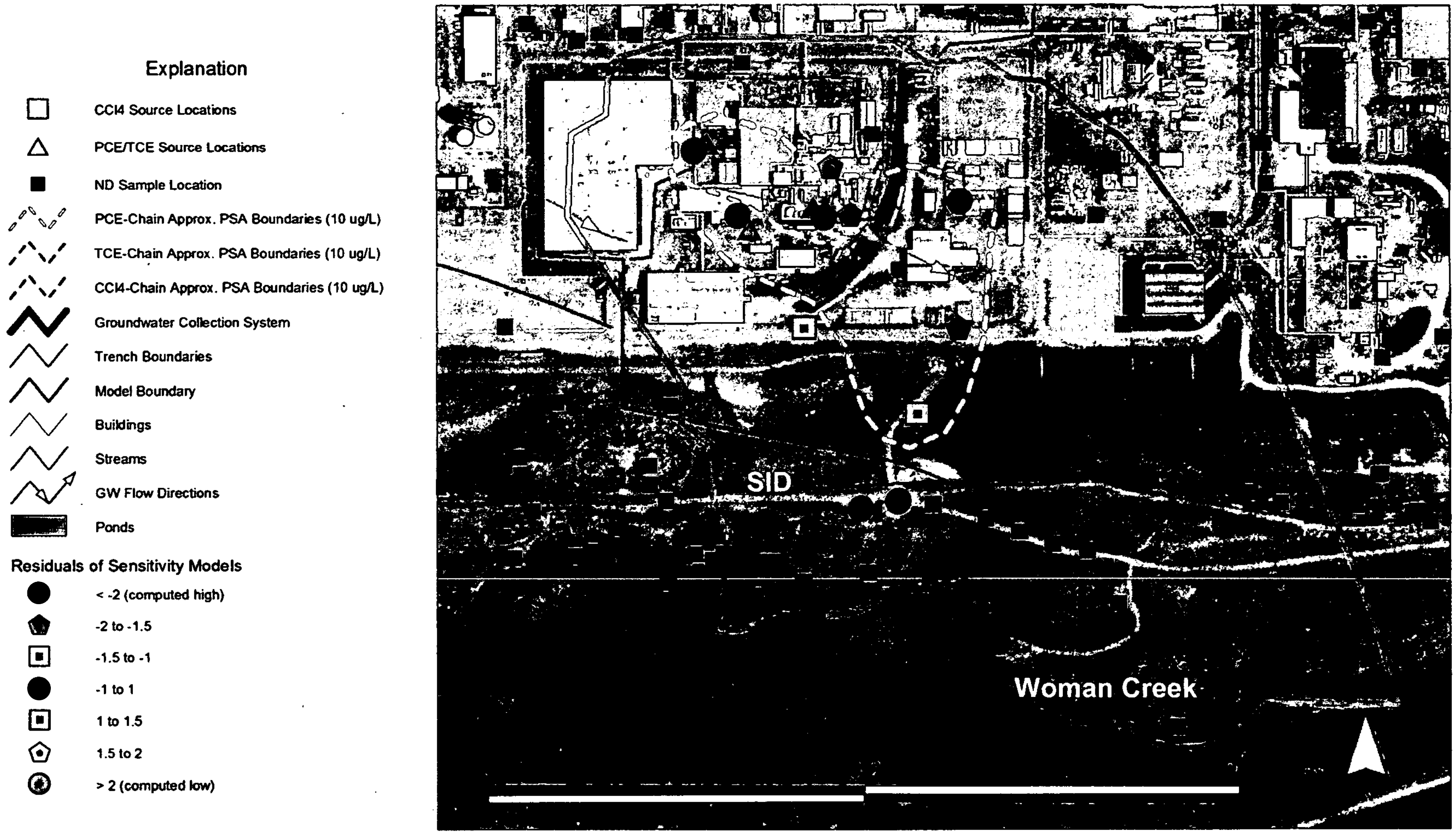

Figure 6.43. PSA 10 – Log residual concentrations. High predicted concentration (TCE) sensitivity run (low degradation).

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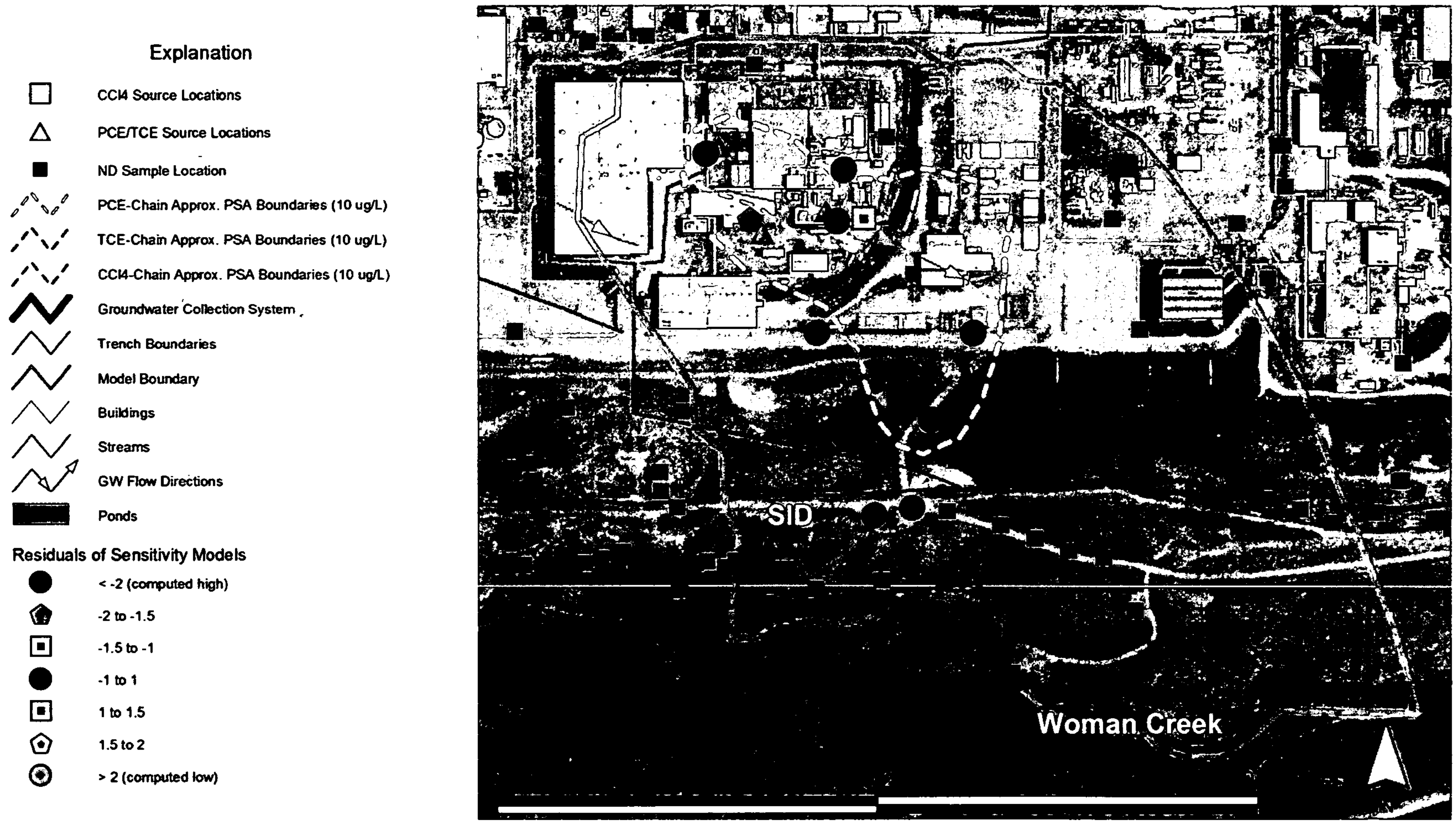

Figure 6.44. PSA 10 – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (high degradation).

A total of 16 transport simulations were run using the PSA 10 model. All runs were simulated for 100 years to establish steady long-term concentrations with time at the southern PSA 10 extent, along Woman Creek and the SID. Figure 6.45 shows simulated groundwater concentrations for the 16 sensitivity runs at selected groundwater discharge locations along Woman Creek and the SID. Simulated steady-state concentrations ranged from non-detect (zero) to a approximately 0.04 mg/L. Therefore, none of 16 simulated steady-state concentrations for PCE, or TCE at groundwater discharge locations along the SID, or Woman Creek were higher than the draft surface water PRGs.

On Figure 6.46, simulated steady-state VOC mass flux from the PSA 10 model area shows that the simulated dominant loss mechanism for VOCs was biodegradation. Only a small fraction is lost as baseflow to the SID and Woman Creek.

6.2.1.7 PSA 12 (Central IA)

The PSA 12 model area, located in the Central IA, contains buildings 551, 559, and 371. The model area is defined on Figure 6.1 and Figure 6.47. Three separate PSAs were defined within the PSA 12 model area (PSA 11, PSA 12, and PSA 13) for the PCE/TCE-chain, and only one PSA (described in Appendix B).

6.2.1.7.1 Groundwater Water Model Results

Constant heads were specified around the entire perimeter of the PSA 12 model area to simulate both groundwater inflow and outflow. The stream located between Buildings 371 and 771 was simulated as a discharge boundary using the MODFLOW river package.

Simulated water balance results indicated that discharge was mainly to ET, baseflow to the stream located between Building 371 and 771, and to drains in the area. Simulated heads compared well to observed groundwater levels; residuals were generally less than 1 meter (as shown on Figure 6.48).

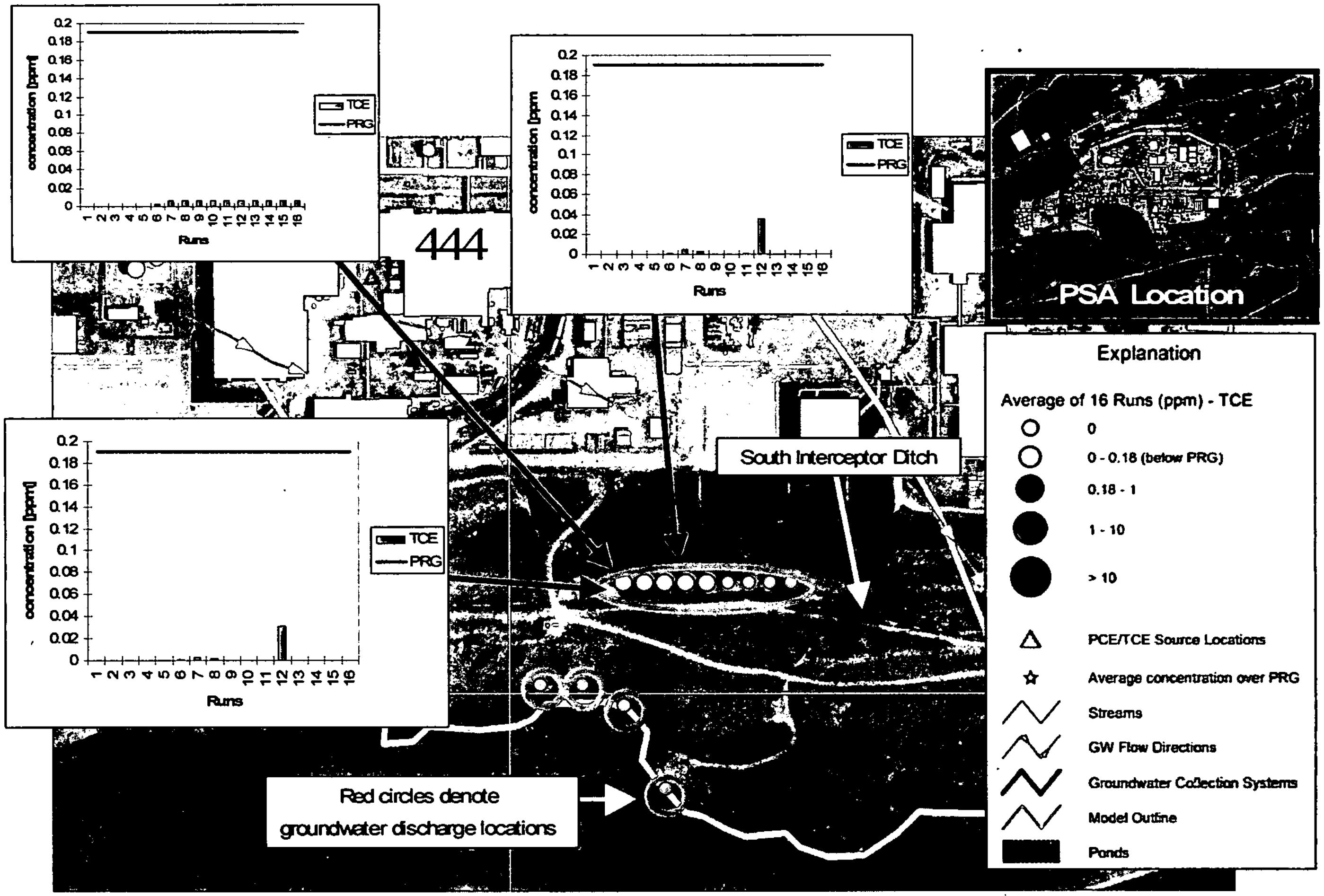

Figure 6.45. PSA 10 - Simulated steady-state TCE groundwater concentrations at groundwater discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

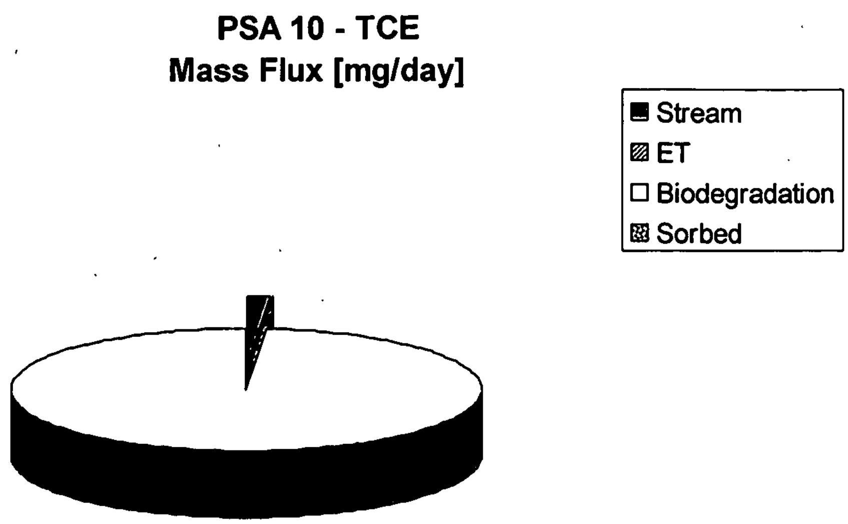

Figure 6.46. PSA 10 - Steady-state mass flux for TCE.

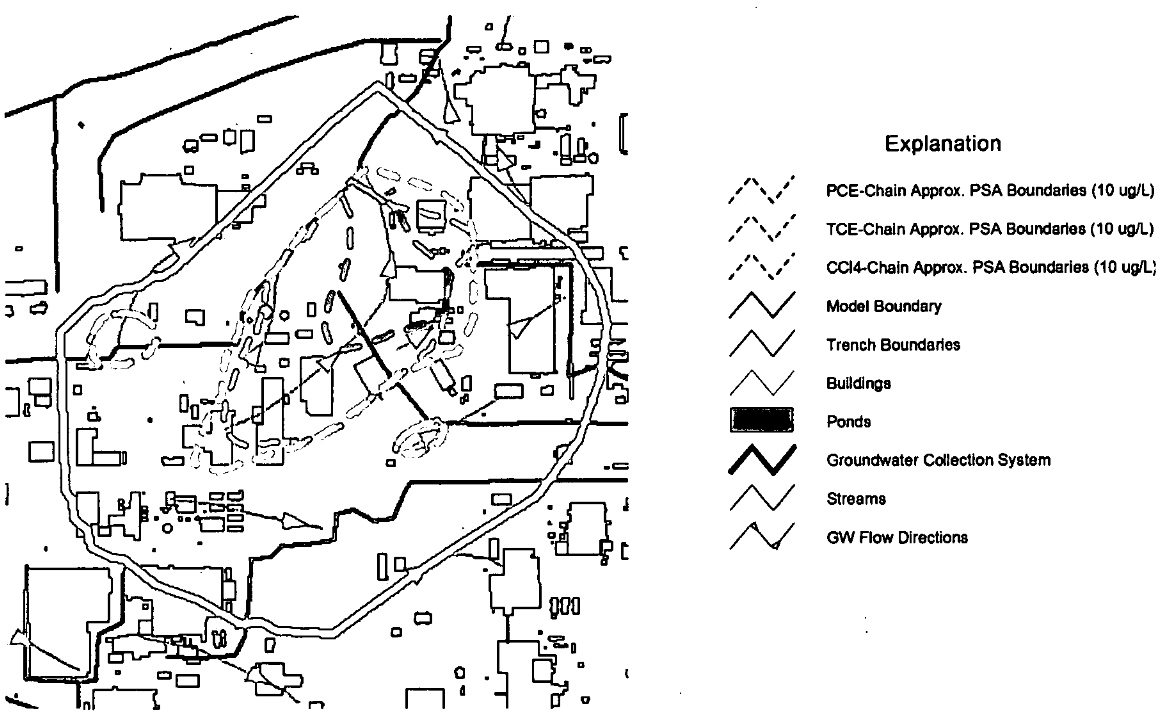

Figure 6.47. PSA 12 - Model area and PSA 11, PSA 12 and PSA 13.

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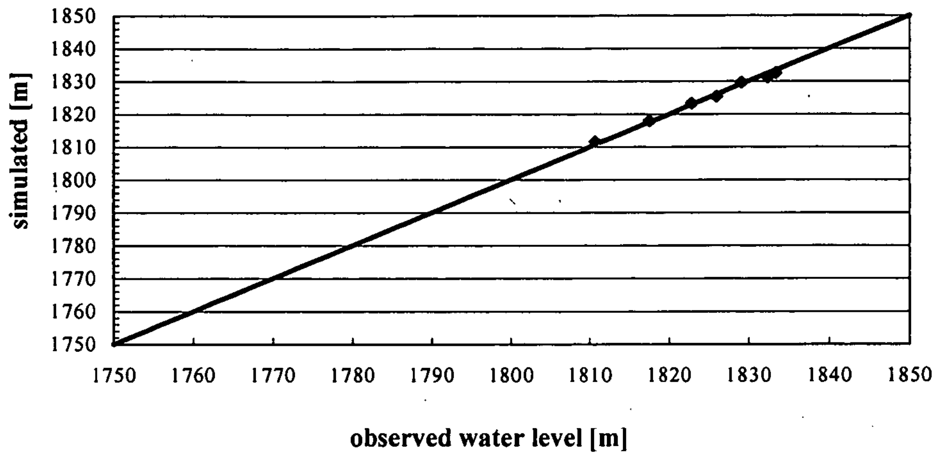

Figure 6.48. PSA 12 - Simulated versus average observed annual groundwater levels (meters above msl).

6.2.1.7.2 Simulated Groundwater VOC Sources

Several VOC source areas were inferred within the PSA 12 model area based on HRR information. Many Priority 1 and Priority 2 releases were identified (Appendix A). Within the PSA 12 model area, sources were inferred for each of the PSAs, for example:

- PSA 11, shown on Figures B-1 through B-4 (Appendix B), does not include Priority 1 or Priority 2 releases, but a source was inferred west of a former control building based on interviews with SMEs;

- PSA 12, shown on Figures B-1 through B-4 (Appendix B), contains several Priority 1 and Priority 2 releases. Releases include: "B371 Parking Lot", associated with solvent and oil grease in 1971; the "North Chemical Storage" and "Middle Chemical Storage", associated with solvent and oil grease (HRR Reference No. 11 and 320, respectively, in Appendix A) and identified between 1959 and 1971; "Building 551 Chemical Leaks", associated with solvent and oil grease and identified in 1974; "Valve Vaults", associated with solvent and oil grease and identified in 1971; and "Scrap Metal Sites", associated with oil grease and identified in 1958 (HRR Reference No. 12 in Appendix A); and

- Only VC within the PSA 13 area was higher than draft surface water PRG values. This area, shown on Figures B-1 through B-4 (Appendix B), contains two Priority 1 releases. The releases were associated with the "Oil Burn Pit" and the "Solvent Burning Ground" (HRR Reference No. 6

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and 179, respectively, in Appendix A). These sites were identified between 1956 and 1961 and included oil grease and solvents.

6.2.1.7.3 Particle Tracking Results – Historical Conditions

Particles were introduced into the lower unconsolidated material model at inferred VOC source locations and allowed to travel for 50 years based on HRR information. Particles were introduced into the lower unconsolidated material because the relatively thick unconsolidated material remained saturated in steady-state flow model simulations.

Particle tracking results (shown on Figure 6.49) confirmed that assumed source depths, locations, and release timing were reasonable. Distances traveled in the assumed 50 years did not extend beyond any of the assumed PSAs except for PSA 13 (see Figures B-1 to B-4 in Appendix B).

6.2.1.7.4 Transport Model Results – Historical Conditions

In the PSA 12 area, TCE was detected above the draft surface water PRG level (0.19 mg/L), PCE was detected at a maximum average historical concentration of 0.31 mg/L (below the draft surface water PRG level of 1.46 mg/L), and CCl_4 was detected above the draft surface water PRG levels (0.58 mg/L). The CCl_4-chain was not observed at concentrations above the draft PRG for PSA 11 and 13. Only concentrations of VC at PSA 13 were above the draft PRG. A total of nine PCE/TCE chain sources were inferred. Only three CCl_4 sources were inferred.

The PSA 13 area was unique in that observed VC concentrations at two sample locations exceeded the PRG, while PCE and TCE (parent compounds of VC) were not detected at or above PRG values. VC has a high vapor pressure and is typically present as a gas at temperatures above –14C°. To reproduce the time-averaged concentration distribution of VC (as a degradation product) in the PSA 13 area, PCE and TCE concentrations had to be specified well above the time-averaged concentrations at the inferred VC source locations. Results of model simulations indicated that VC degraded to concentrations below PRG values for closure simulations using a range of VC degradation similar to those specified for other PSA models.

Plots showing the log residual concentrations for TCE (i.e., log of time-averaged minus simulated concentrations) are shown on Figures 6.50 and 6.51. Results of sensitivity runs indicated that the highest down-gradient concentrations (Figure 6.50) were produced with low degradation values and the lowest down-gradient concentrations (Figure 6.51) were produced with high porosity values. Emphasis was placed on reproducing down-gradient wells, as near-source well concentrations may not reflect well-mixed groundwater concentrations.

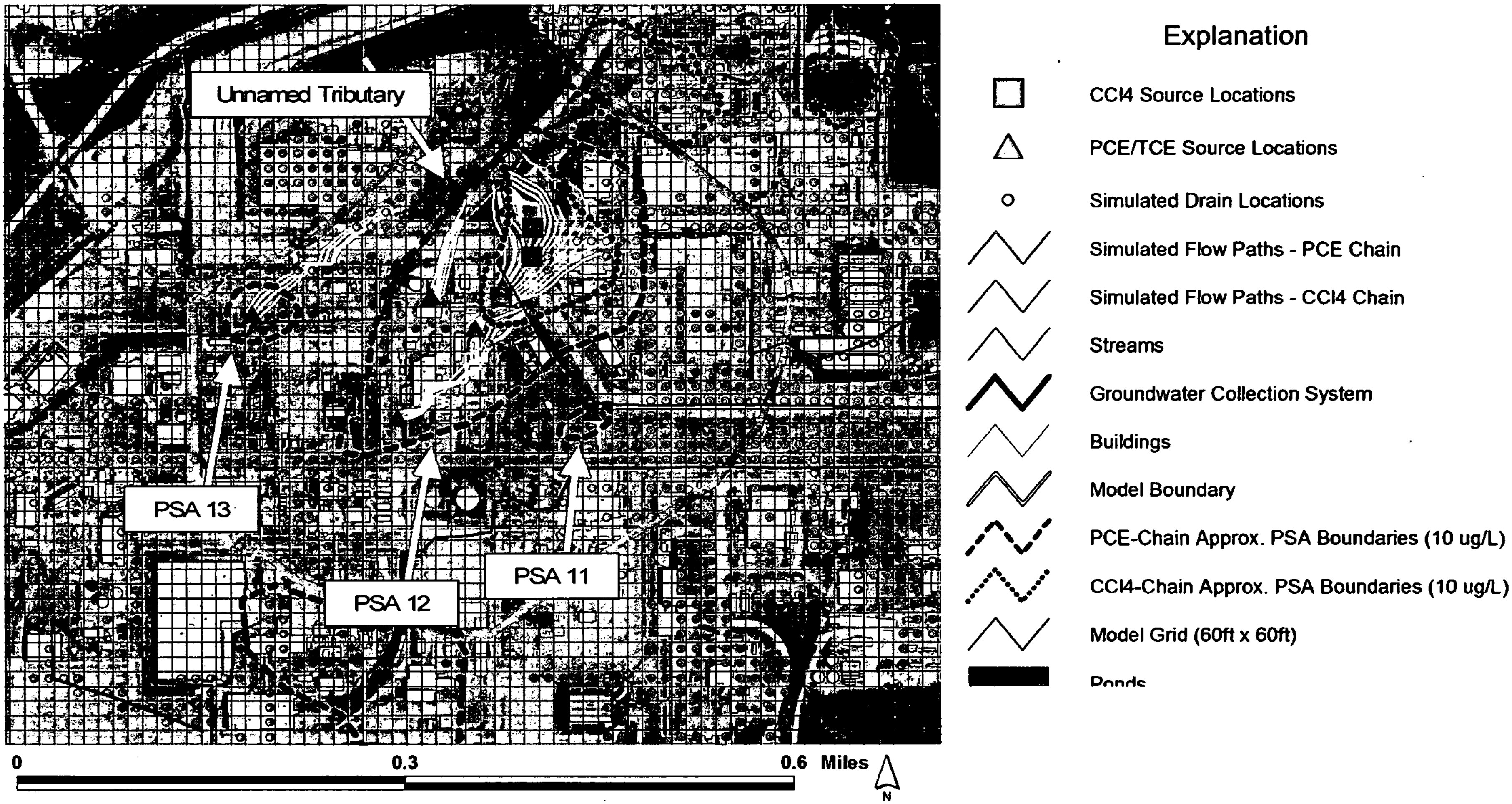

Figure 6.49. PSA 12 - Simulated flow paths (after 50 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

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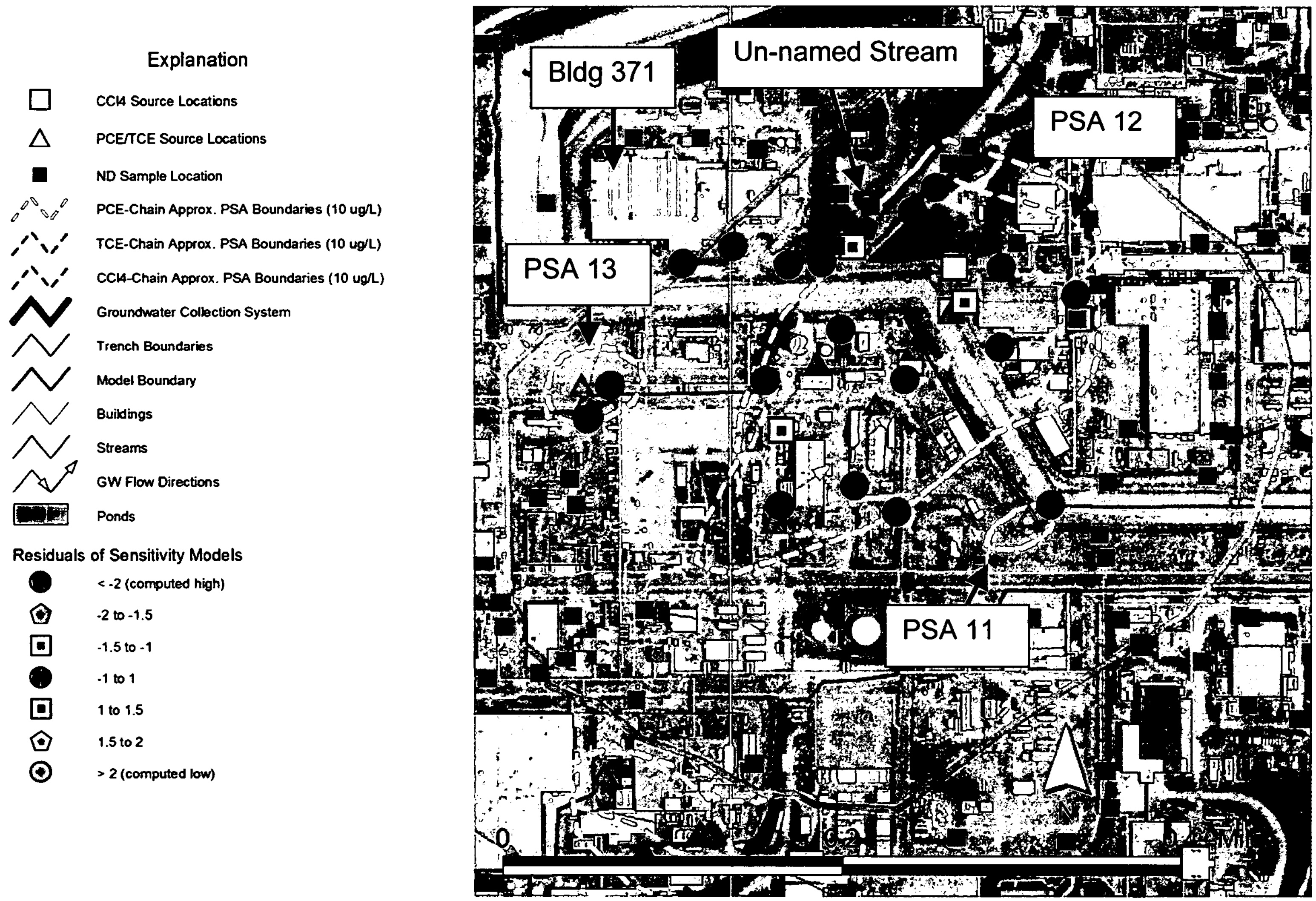

Figure 6.50. PSA 12 – Log residual concentrations. High predicted concentration (TCE) sensitivity run (low degradation).

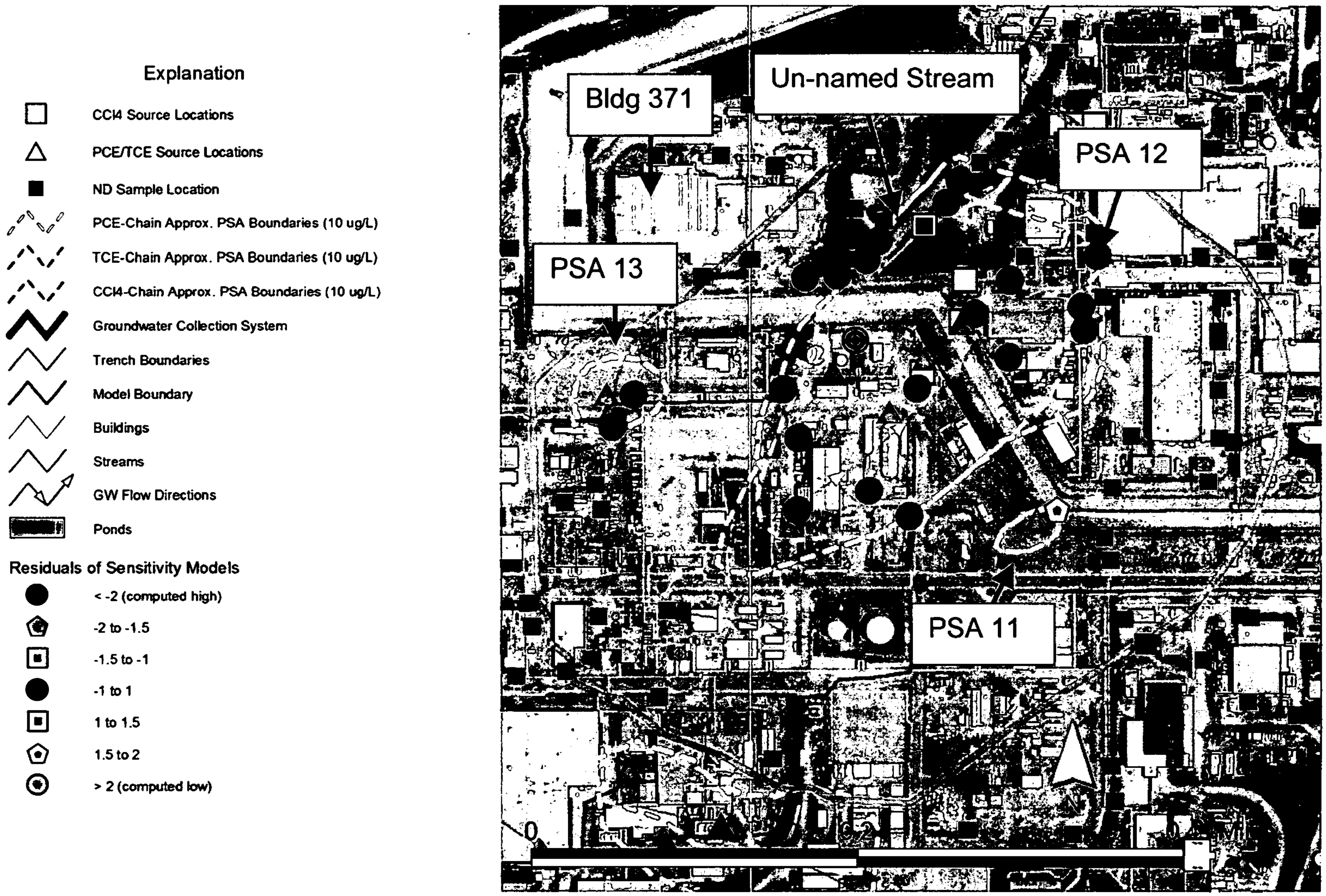

Figure 6.51. PSA 12 – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (high porosity).

Model simulations indicated that groundwater travels in the upper unconsolidated material and discharges as ET, or baseflow to the IA drainage between buildings 371 and 771. Surface water VOC concentration data were unavailable to confirm simulated groundwater concentrations at the IA drainage in this PSA.

Sensitivity simulations bracketed the observed time-averaged parent/daughter concentrations of parent and daughter products and performed as expected for each parameter change (based on descriptions in Table 6.3). The time-averaged concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain and chloroform and methylene chloride for the CCl_4 degradation chain) was bracketed by the various sensitivity runs, with high concentrations (simulated high daughter product concentrations) and low degradation (simulated low daughter product concentrations) cases for the PCE degradation chain. Results are shown on Figure D-11 and Figure D-12 of Appendix D.

6.2.1.7.5 Transport Model Results – Closure Configuration

Groundwater in the PSA 12 model area under current conditions flowed to the north (towards Walnut Creek) within the upper unconsolidated material and lower weathered bedrock. Under the closure configuration changes to the groundwater flow directions did not significantly impact the PSA 12 area.

A total of 16 transport simulations were run using the PSA 12 model. All runs were simulated for at least 100 years to establish steady long-term concentrations with time at the PSA extent along the stream located between Building 371 and 771. Simulated long-term TCE and CCl_4 groundwater concentrations at discharge locations along the tributary in the northwestern model area for the 16 model simulations are summarized on Figures 6.52 and 6.53, respectively. For these runs, steady-state simulated concentrations ranged from zero to a maximum of approximately 0.18 mg/L for TCE and 0.1 mg/L for CCl_4. Therefore, none of 16 simulated steady-state concentrations for PCE, TCE, or CCl_4, at groundwater discharge locations along the SID, or Woman Creek, were higher than the draft surface water PRGs.

Results of the PSA 12 model transport simulations indicate that the dominant loss mechanisms for VOCs are biodegradation and ET (Figures 6.54 and 6.55).

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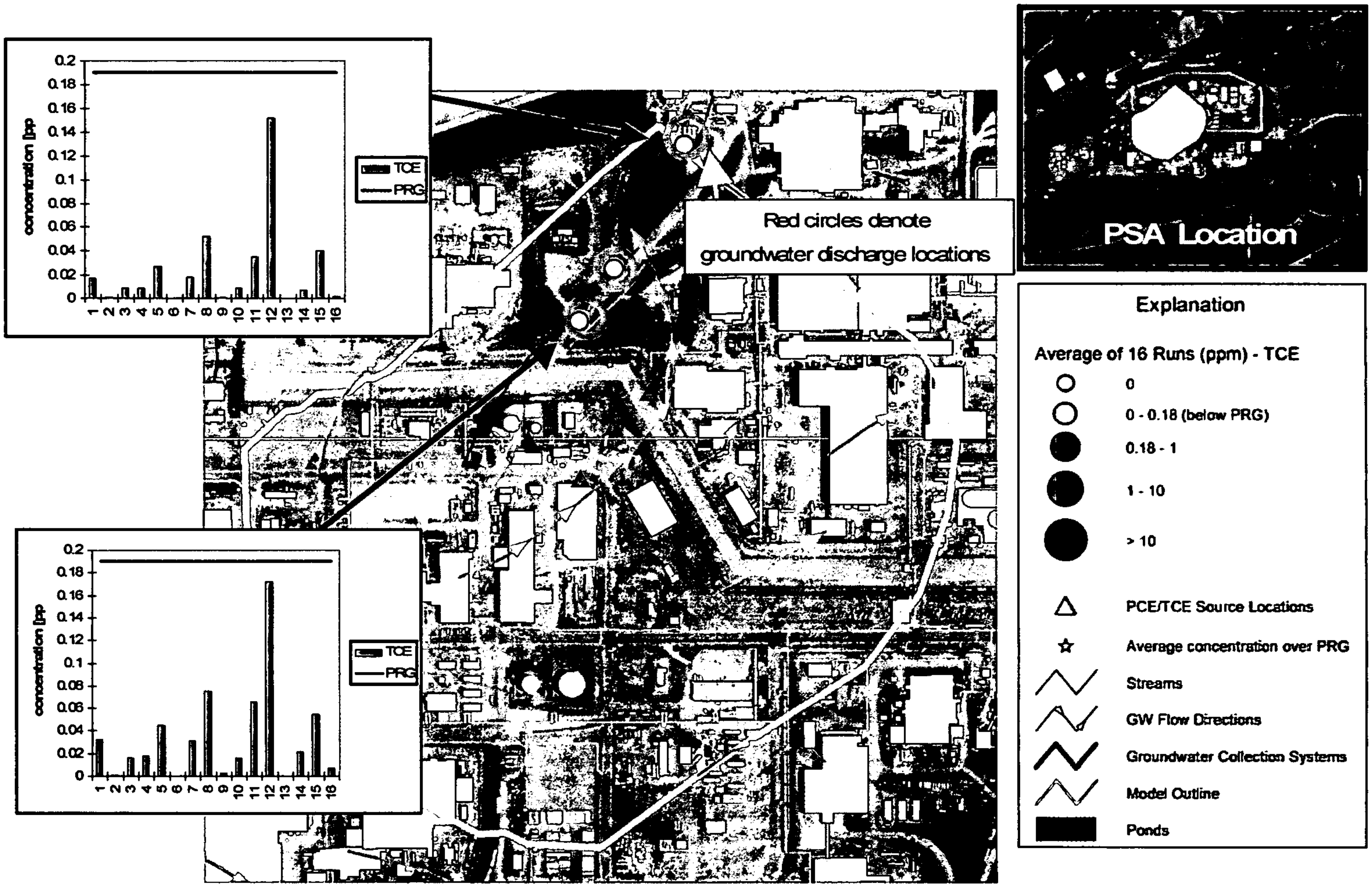

Figure 6.52. PSA 12 - Simulated TCE groundwater concentrations at groundwater discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

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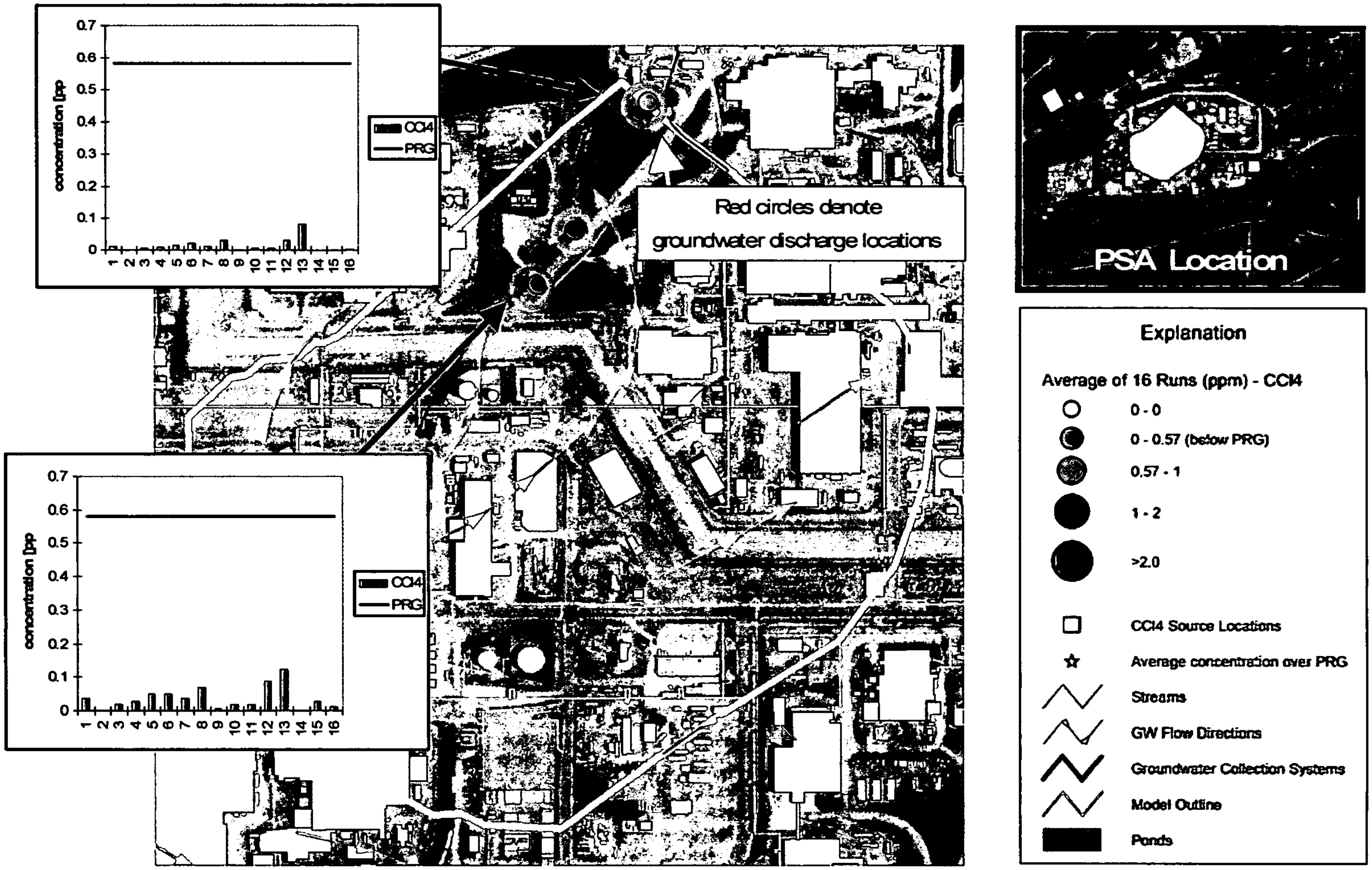

Figure 6.53. PSA 12 - Simulated CCl_4 groundwater concentrations at groundwater discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

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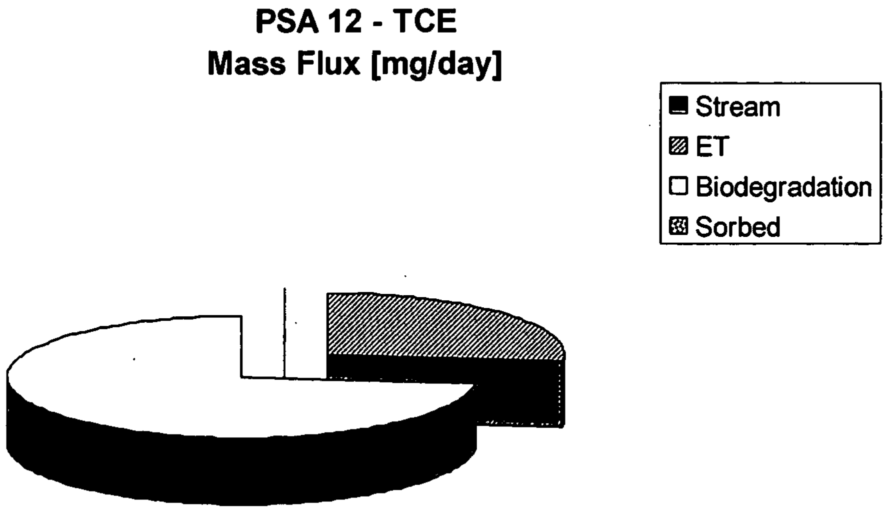

Figure 6.54. PSA 12 - Steady-state mass flux for TCE.

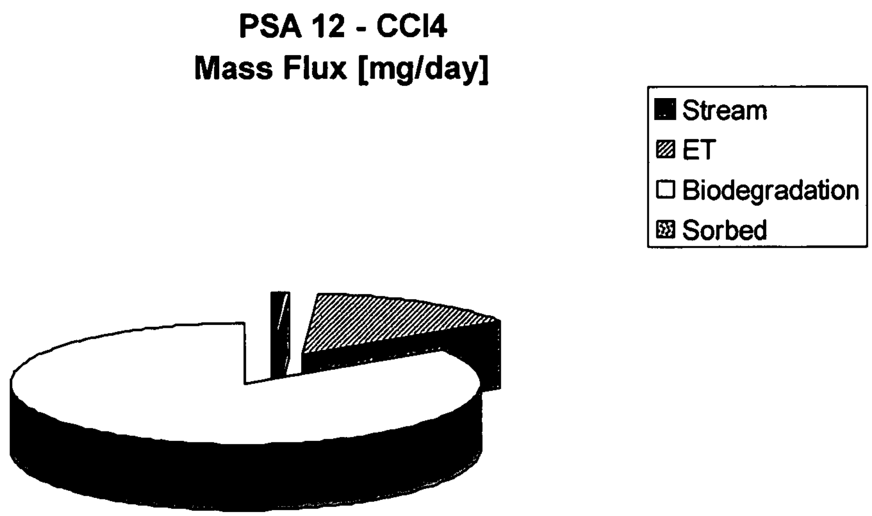

Figure 6.55. PSA 12 - Steady-state mass flux for CCl_4.

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6.2.1.8 PSA 14 (Building 771 – IHSS118.1 Area)

The PSA 14 model area is located in the Building 771 area, and it is defined on Figure 6.1 and Figure 6.56. Only CCl_4 was simulated in the model area because PCE-chain concentrations were lower than draft surface water PRGs.

6.2.1.8.1 Groundwater Flow Model Results

Constant heads were specified along the entire model perimeter to simulate both groundwater inflow and discharge. Stream flow within the North Walnut Creek and tributary between Building 771 and 371 were simulated using the MODFLOW river package. Only groundwater discharge along these streams was simulated in the steady-state flow model.

Simulated hydraulic heads compare well with observed groundwater well water levels and residuals range from one to two meters (Figure 6.57). Simulated water balance results indicated groundwater discharged mostly as ET, and to a lesser extent, as baseflow or drain flow.

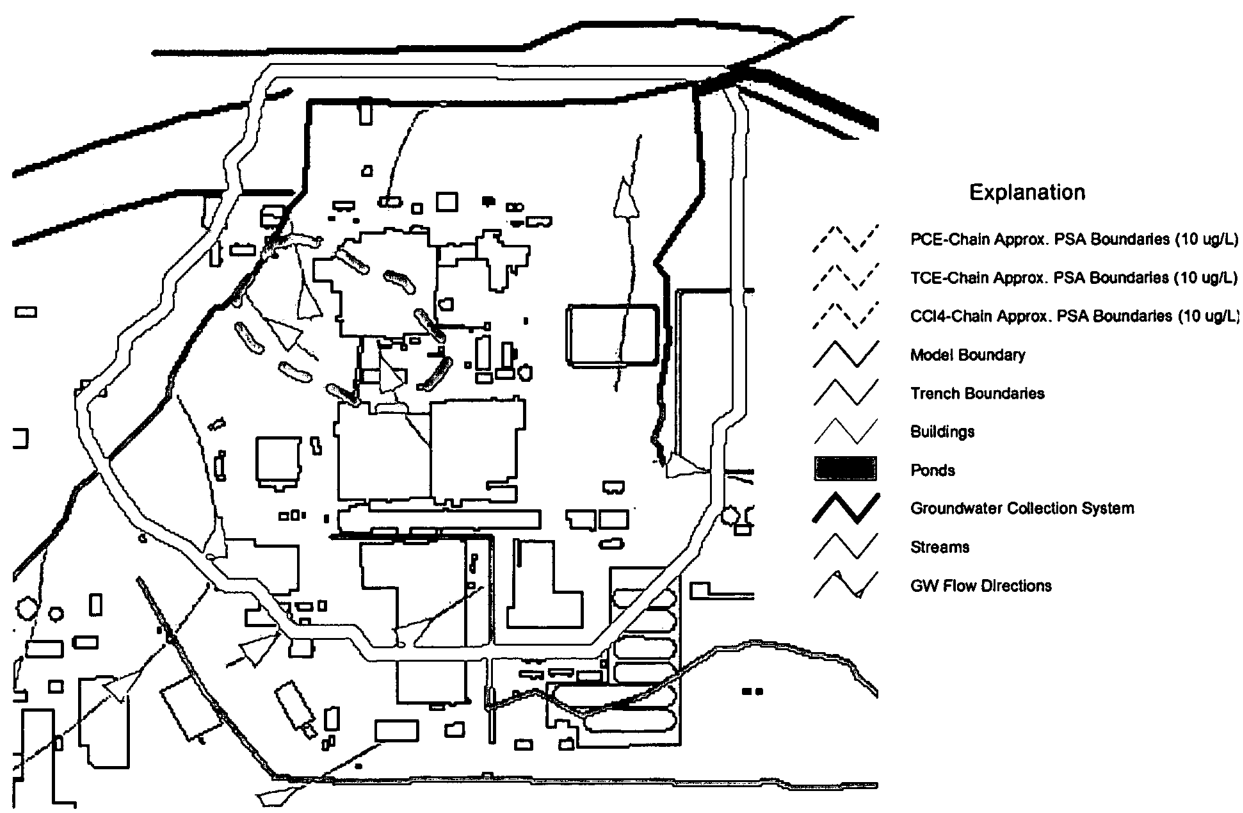

Figure 6.56. PSA 14 - Model area and PSA.

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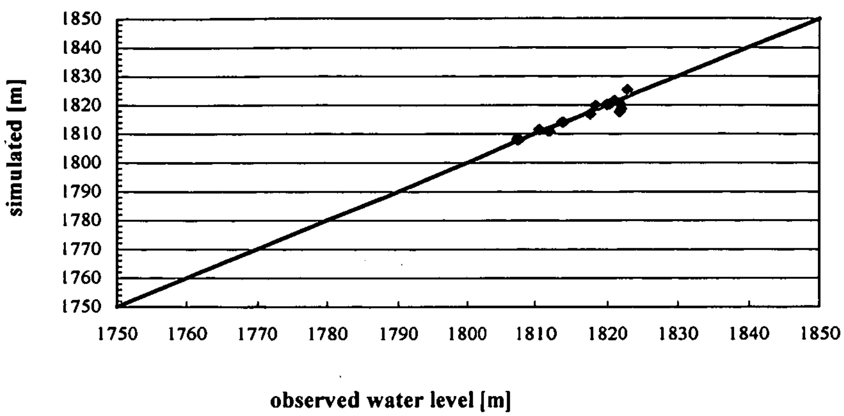

Figure 6.57. PSA 14 - Simulated versus average observed annual groundwater levels (meters above msl).

6.2.1.8.2 Simulated Groundwater VOC Sources

Only the CCl_4-chain was observed at concentrations above the draft PRG. Estimated PSA boundaries for the CCl_4-chain are shown on Figures B-5 through B-7 (Appendix B). One known release is found in the area and is located north of the Building 776/777 area and south of Building 771. This source is well known (IHSS 118.1) and NAPL has been observed (based on information from SMEs) at the interface between the unconsolidated material and weathered bedrock during field characterization. Historical release information indicates this is a Priority 1 release, identified as "Multiple Solvent Spills west of Bldg. 730", and "South End of Building 776 Solvent Spill" (HRR Reference No. 18 through 20 in Appendix A). The HRR describes the priority area as a CCl_4 tank discovered leaking prior to 1970. Several occurrences of leaking CCl_4 (with vague or unknown dates and volumes) were noted in the HRR both before and after this time. The source area for this release is represented by three model cells.

Another CCl_4 source was inferred west of the known release to reproduce the comparatively high time-averaged concentrations in wells located on the hillslope above the tributary between Building 771 and 371. Time-averaged concentrations in these wells are above the draft surface water PRG values. No known HRR release, or likely source area, could be clearly identified in the area to account for these higher concentrations. Though, model simulations indicated that an inferred source in this area could reproduce time-averaged parent and daughter concentrations in downgradient wells, the location, depth, and source concentration remain unknown.

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6.2.1.8.3 Particle Tracking Results – Historical Conditions

Particles were introduced into the model at the inferred VOC source locations described above, and then allowed to travel for 50 years (Figure 6.58). Particles were entered into the weathered bedrock because the relatively thin overlying unconsolidated material (<3 meters) was largely unsaturated in the source area. Particle tracking results generally confirmed that assumed source locations, depths, and travel times are reasonable. Flow paths to the north beneath the building over-predicted the PSA extent because the affects of the Building 771 footing drains were not captured accurately with the resolution of this model and the flow paths did not consider affects of attenuation processes (i.e. sorption or degradation) on the travel distances.

6.2.1.8.4 Transport Model Results – Historical Conditions

Plots showing the log residual concentrations for CCl_4 (i.e., log of observed minus simulated concentrations) are shown on Figures 6.59 and 6.60. Results of sensitivity runs showed that the highest simulated concentrations (Figure 6.59) at well locations were produced with low degradation values, while the lowest concentrations (Figure 6.60) were produced with high degradation values. Emphasis was placed on reproducing down-gradient wells, as near-source well concentrations may not reflect well-mixed groundwater concentrations.

Overall, model simulations indicated that VOC concentrations were removed from the groundwater due to several processes:

- As groundwater moves away from the VOC source, flow was impeded when it reached the extent of the Arapahoe Sandstone to the north and west (Figure 3.1 and 3.2), where it encounters the relatively lower-conductivity weathered bedrock. Slower groundwater flow rates resulted in longer residence times, increasing the potential for degradation. The slower flow rates in the model are due to the thinning of sandstone in the direction of flow, and transition into the lower conductivity claystone/siltstone;
- Increasing ET effects as groundwater nears streams decreased concentrations at stream areas; and
- The effects of the footing drain for Building 771 (south end) removed contaminants and reduced migration of CCl_4 from the inferred VOC source area to the south. Footing drains also decreased local heads by redirecting flows towards it.

Overall the PSA 14 model sensitivity simulations bracketed the observed average historical concentrations of parent and daughter products and performed as expected for each parameter change (based on descriptions in Table 6.3). The observed concentration distribution of daughter products (chloroform and methylene chloride for the CCl_4 degradation chain) was bracketed by the various sensitivity runs, with high concentrations (producing high daughter products) and

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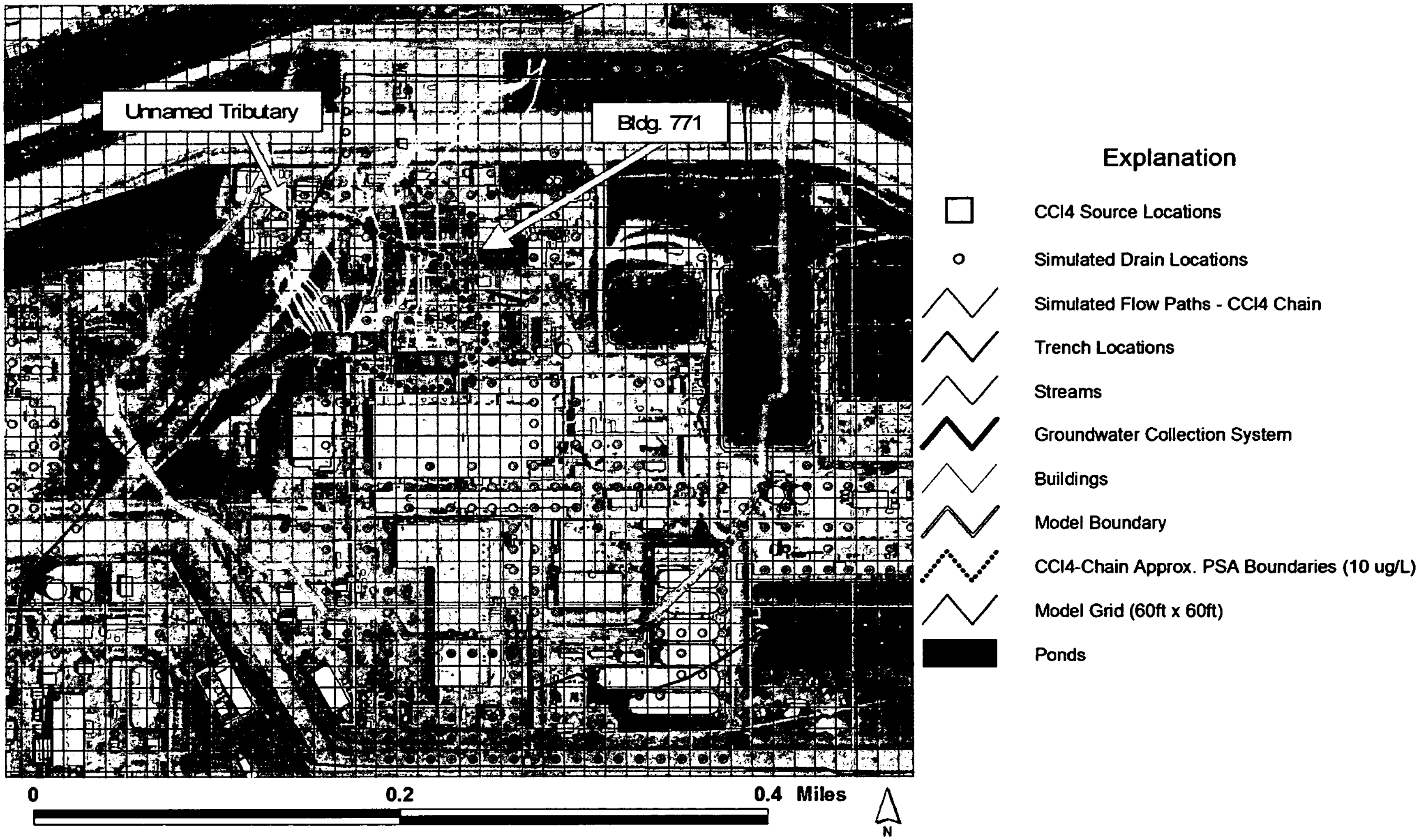

Figure 6.58. PSA 14 - Simulated flow paths (after 50 years). Particles introduced into the lower unconsolidated layer and weathered bedrock.

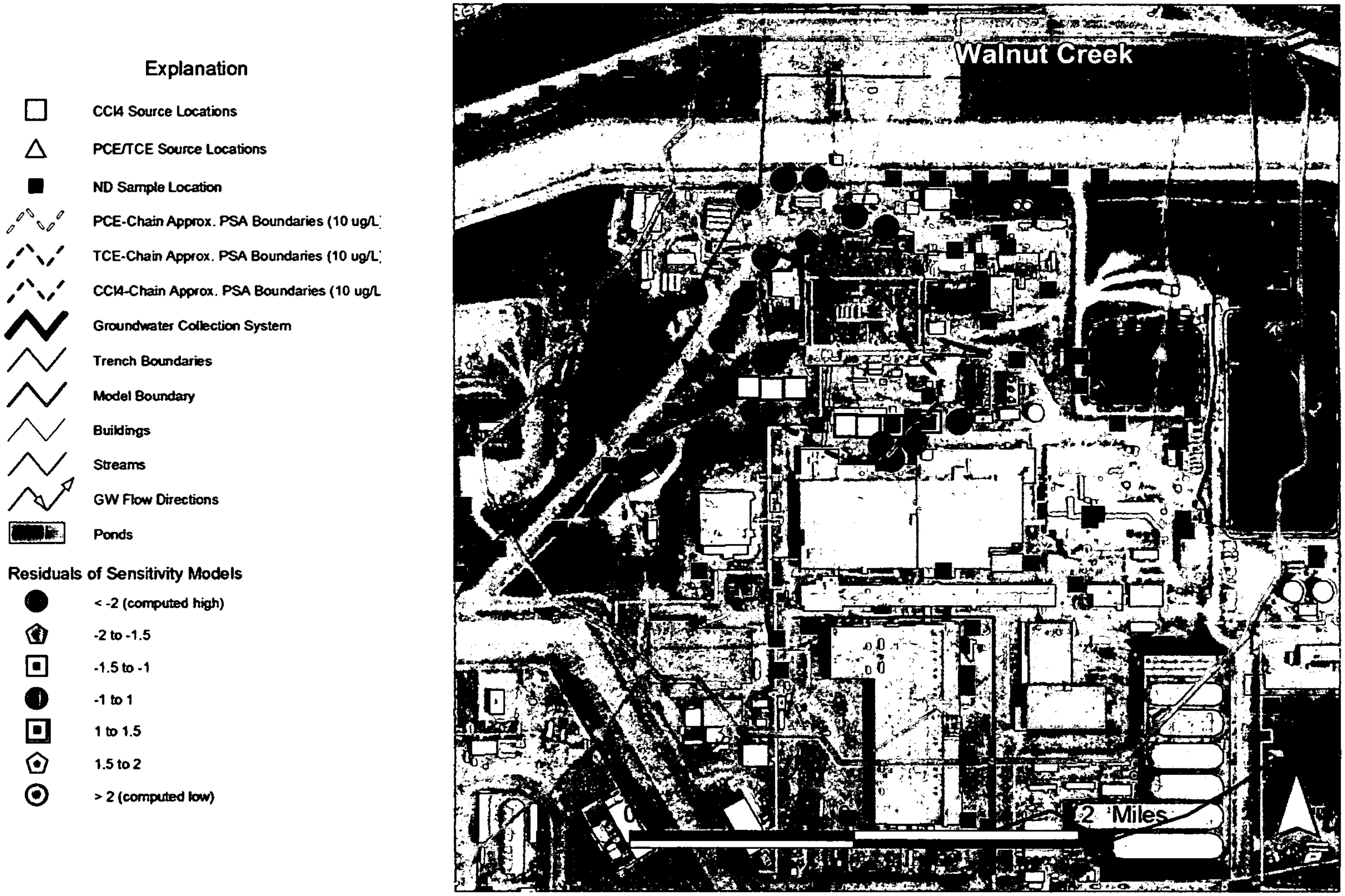

Figure 6.59. PSA 14 – Log residual concentrations. High predicted concentration (CCl_4) sensitivity run (low degradation).

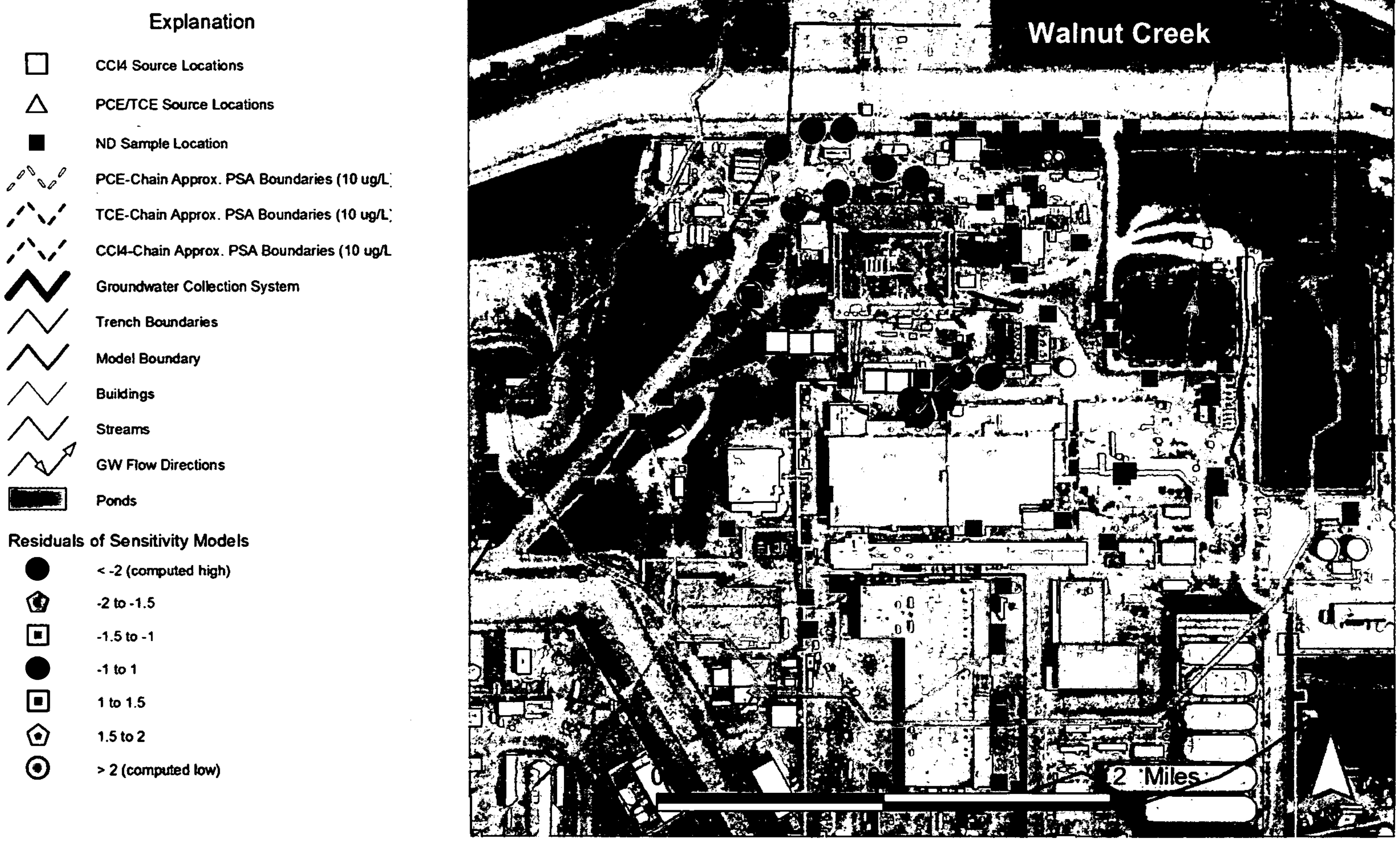

Figure 6.60. PSA 14 – Log residual concentrations. Low predicted concentration (CCl_4) sensitivity run (high degradation).

low degradation (producing low daughter products) cases for the CCl_4 degradation chain. The results are shown on Figure D-13 and Figure D-14 of Appendix D.

6.2.1.8.5 Transport Model Results – Closure Configuration

In the PSA 14 model area, groundwater under current conditions flowed to the north and northwest towards the nearby streams. Although, integrated flow modeling showed that closure configuration modifications increased heads in the area surrounding Building 771, changes to the flow path were not significant. The only exception was that groundwater north of Building 771 flowed more easterly.

Results of closure configuration transport simulations indicated that the time it takes for CCl_4 to reach steady-state concentrations was approximately 100 years.

A total of 16 transport model runs were simulated. All runs were simulated for at least 100 years to establish steady long-term concentrations with time at the PSA extent along the stream located between Building 771 and 371 and along North Walnut Creek. The simulated groundwater concentrations for the 16 model runs for selected integrated flow groundwater discharge areas are shown on Figure 6.61.

The bar charts on Figure 6.61 show results for discharge locations that were most impacted by CCl_4. Simulated concentrations at these locations ranged from zero (not detected) to approximately 1.0 mg/L along the unnamed tributary west of Building 771. Model results also showed that no significant concentration of CCl_4 occurred in the northern discharge area in the PSA 14 model (North Walnut Creek).

Three model sensitivity runs predicted that CCl_4 above the draft surface water PRG value reached one potential discharge point, located directly west of Building 771 near the unnamed tributary (Figure 6.61). The three model runs that produced the highest concentrations included:

- A combination of low sorption, low porosity, and low dispersivity ;
- Low porosity; and
- Low degradation rates.

With the exception of these three model runs at one discharge point, CCl_4 was not predicted to impact groundwater above draft surface water PRG levels (0.58 mg/L) at any other location. The daughter products of CCl_4, chloroform, and methylene chloride, have draft surface water PRG levels of 20 mg/L and 10 mg/L, respectively, which were not exceeded in any sensitivity simulation.

Attenuation was affected by the shallow groundwater gradient and slower groundwater travel times. These conditions allowed more time for the parent

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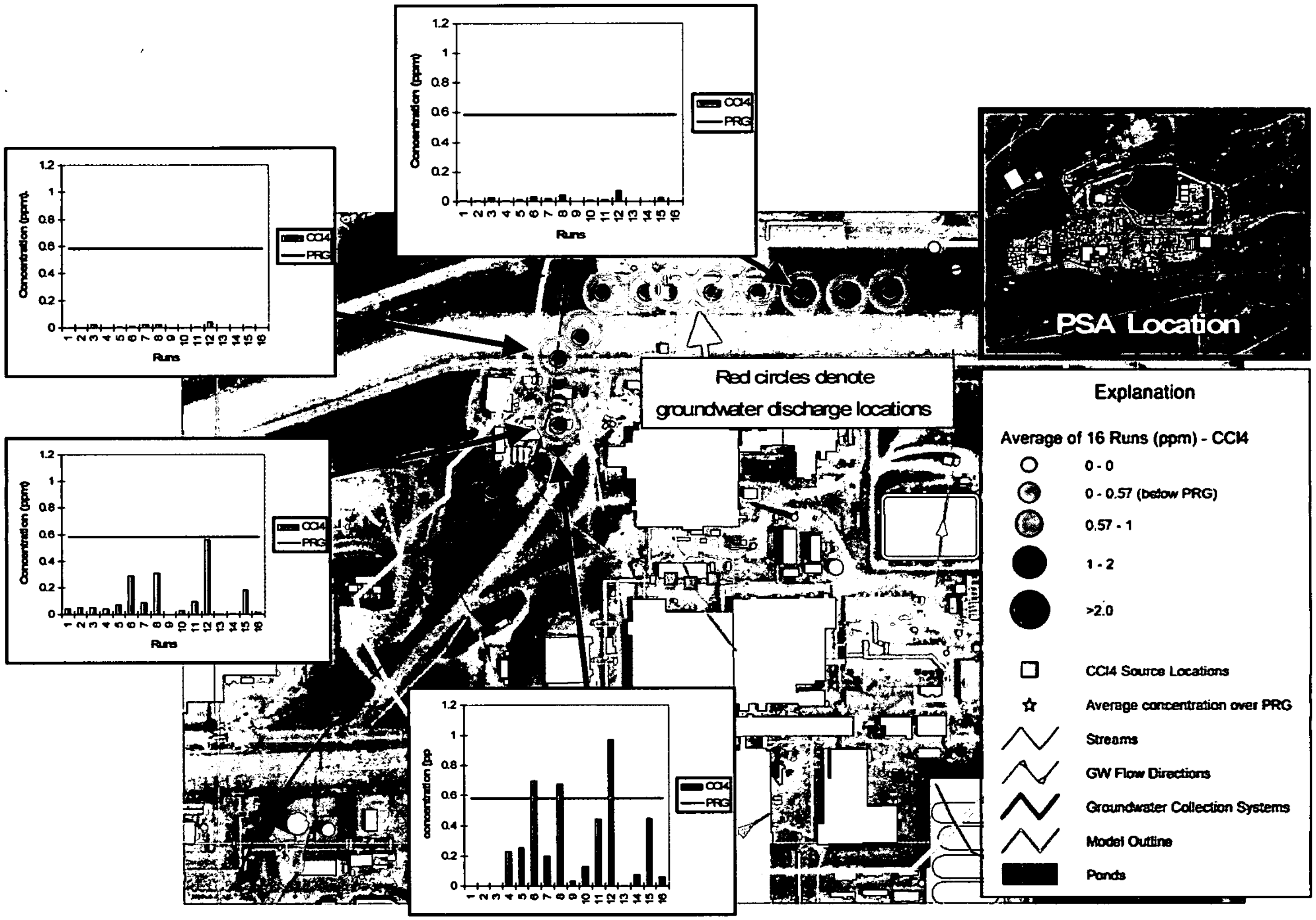

Figure 6.61. PSA 14 - Simulated CCl_4 groundwater concentrations at potential discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

compound to degrade to daughter products (chloroform and methylene chloride). Additionally, a body of Arapahoe Sandstone within the lower weathered bedrock layers (shown on Figure 2.3 and Figure 2.4) allowed for groundwater to flow through the lower weathered bedrock layers, where it moved very slowly due to the discontinuous nature of the sandstone.

Mass flux from the transport model indicated that the simulated dominant loss mechanisms for VOCs were biodegradation and ET (Figure 6.62).

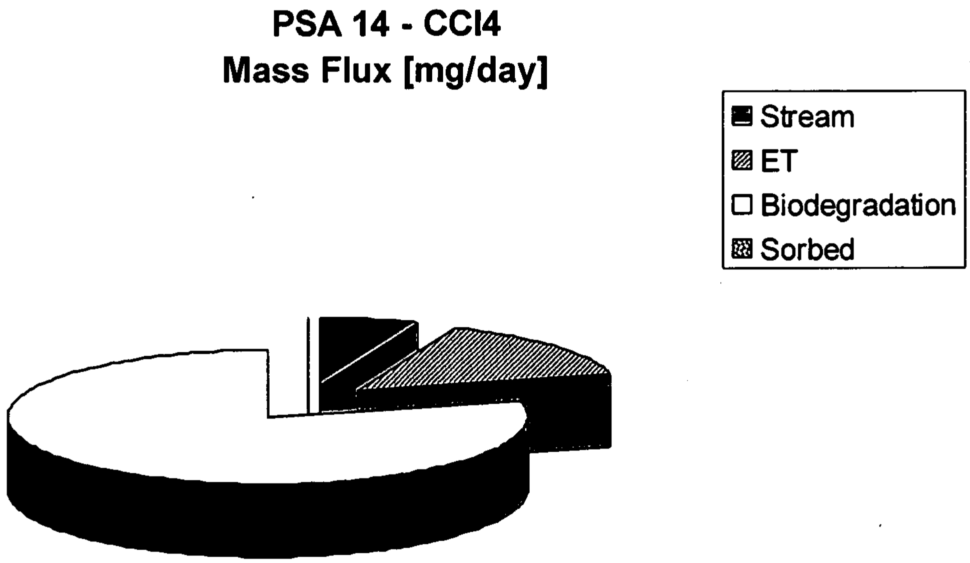

Figure 6.62. PSA 14 - Steady-state mass flux for CCl_4.

6.2.1.9 PSA 15 (Former Western Solar Ponds Area)

The PSA 15 model area is located within the "former Solar Ponds" area, and is defined on Figures 6.1 and 6.63.

6.2.1.9.1 Groundwater Flow Model Results

Constant head boundaries for PSA 15 were placed at the western and southern up-gradient boundaries where groundwater flow enters the model, as well as the northern down-gradient boundary where flow exits the model.

Simulated water balance results indicated groundwater discharge occurred mainly as ET and to a lesser extent baseflow, near North Walnut Creek. It also

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discharged to local drains and the Solar Ponds Groundwater Collection System. Simulated hydraulic heads compared well with observed groundwater well water levels; residuals ranged from 1 to 2 meters. (as shown on Figure 6.64).

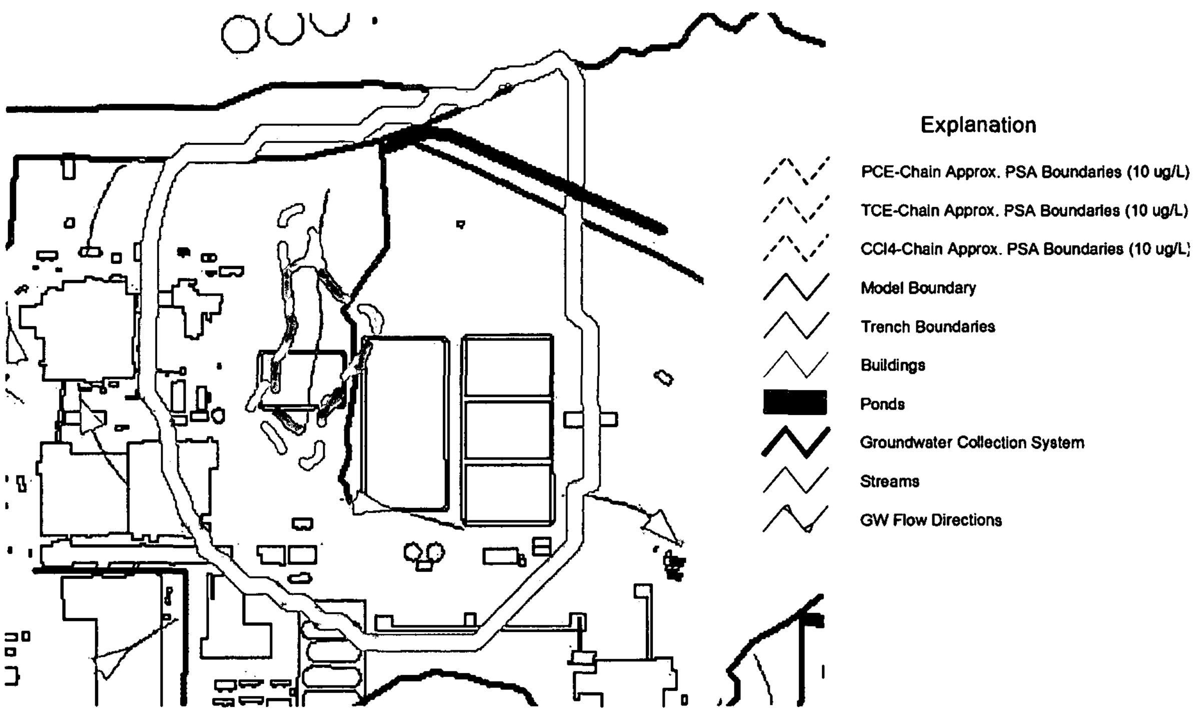

Figure 6.63. PSA 15 - Model Area and PSA.

6.2.1.9.2 Simulated Groundwater VOC Sources

No sources were identified in the HRR information (summarized in Appendix A) for PSA 15. Particle tracking suggested that a source near the former western Solar Ponds area could account for observed well concentrations in the area. As a result, particles were introduced in this area and allowed to travel for 50 years (Figure 6.65). Particles were entered into the upper weathered bedrock because the overlying unconsolidated material is thin and generally unsaturated.

The PSA 15 model area is located within the "former Solar Ponds" area. PSA 15 does not include any priority sources listed in the HRR database. However, particle tracking results suggest that the source of down-gradient PCE/TCE-chain and CCl_4-chain concentrations is likely associated with the (western) former Solar Ponds.

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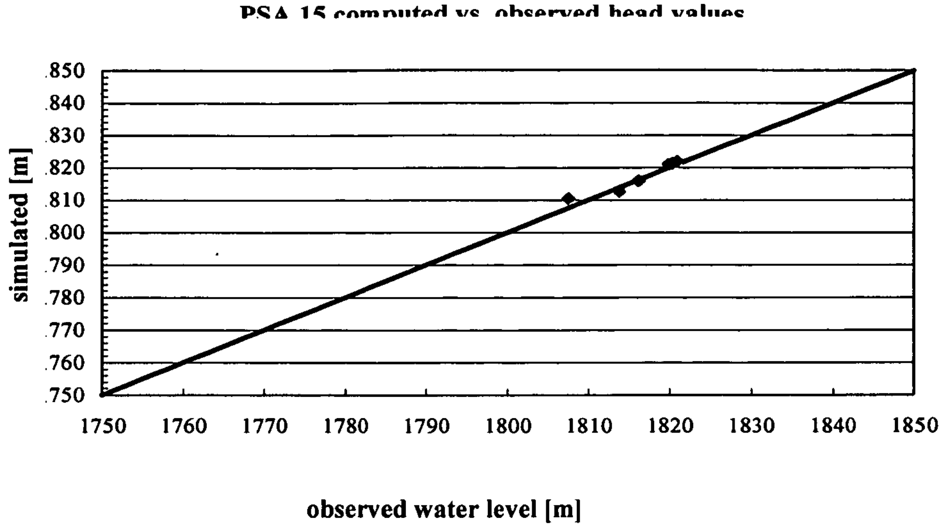

Figure 6.64. PSA 15 - Simulated versus average observed annual groundwater levels (meters above msl).

Both TCE and the CCl_4-chains were observed at concentrations above the draft PRGs and simulated for PSA 15 using the same potential VOC source. PCE was not observed above the draft PRG value. Estimated PSA boundaries for each chain are shown on Figures B-1 through B-7 (Appendix B). The assumed source was represented by two modeled source cells.

6.2.1.9.3 Particle Tracking Results – Historical Conditions

Results shown on Figure 6.65 suggest that the assumed location, depth, and release timing were reasonable. Particles traveled in a north-northeast direction and were intercepted by the Solar Ponds Groundwater Collection System in the model simulations. The assumed PSA 15 extent is reasonable with these assumptions.

6.2.1.9.4 Transport Model Results – Historical Conditions

The simulated closure configuration in the integrated flow model indicated very little change to the groundwater flow paths in the PSA 15 area. This is partly because few changes were proposed in the inferred VOC source area near the western former Solar Ponds area, and no changes were proposed in the hillslope area south of North Walnut Creek.

TCE was detected above the draft surface water PRG level (0.19 mg/L) within the PSA 15 area, PCE was detected at a maximum average historical concentration of 0.008 mg/L (below the draft surface water PRG level of 1.4 mg/L), and CCl_4 was detected above the draft surface water PRG levels (0.58 mg/L). Estimated PSA boundaries for each chain are shown on Figures B-1

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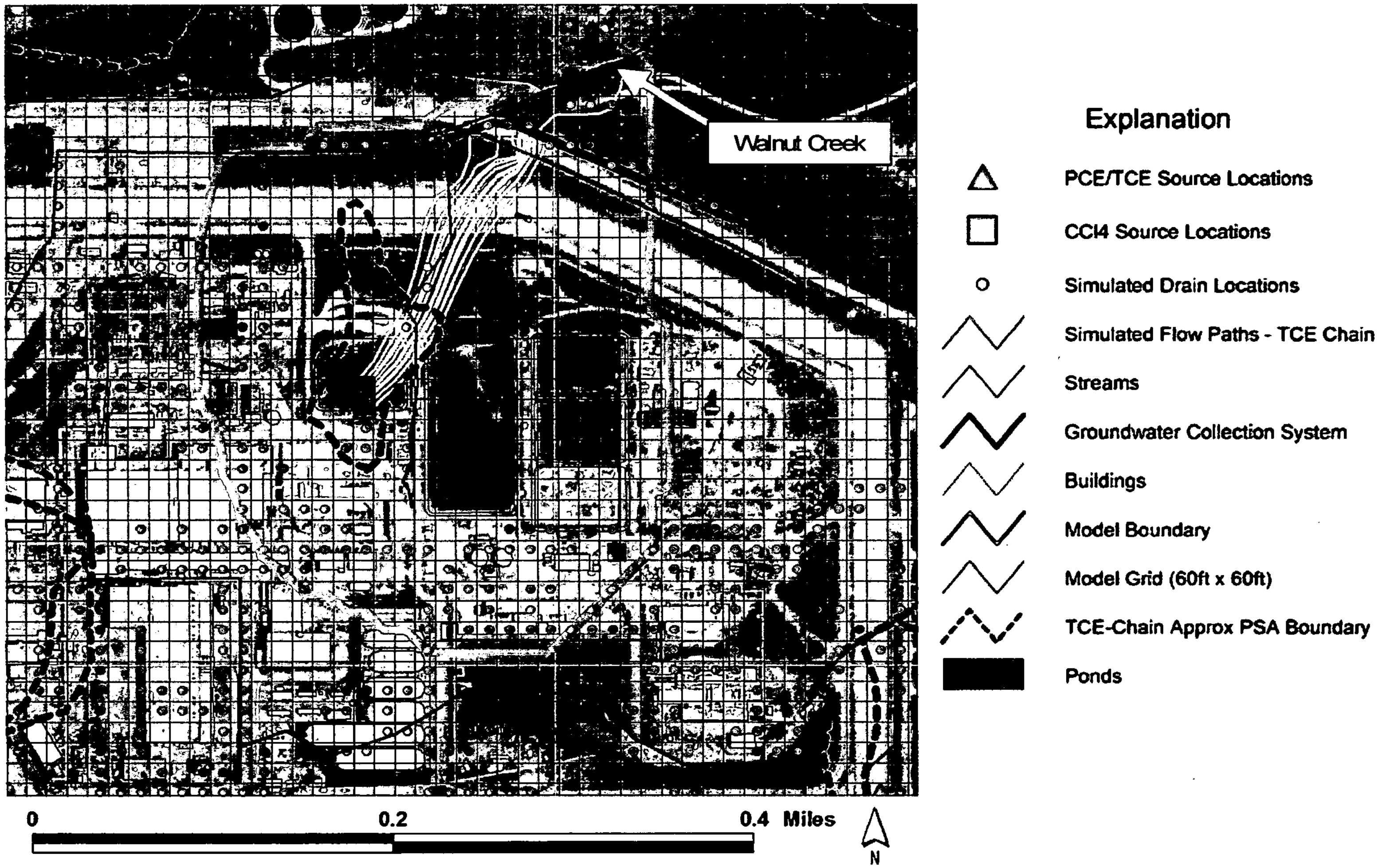

Figure 6.65. PSA 15 - Flow paths of particles introduced into the upper weathered bedrock. Particles were allowed to travel for 50 years.

through B-7 (Appendix B). The assumed source was represented by two modeled source cells.

Plots showing the log residual concentrations for TCE (i.e., log of observed minus simulated concentrations) are shown on Figures 6.66 and 6.67. Sensitivity runs indicated that the highest down-gradient concentrations (Figure 6.66) were produced with low degradation values and the lowest down-gradient concentrations (Figure 6.67) were produced with high degradation rates. Down-gradient (northern) concentrations were very low. Model sensitivities indicated that contaminants did not travel far, so these points were relatively insensitive to changing parameter values. Emphasis was placed on reproducing down-gradient wells, as near-source well concentrations may not reflect well-mixed groundwater concentrations.

Overall, model simulations indicated that VOC concentrations were removed from the groundwater due to the following processes:

- As groundwater moves away from the VOC source, flow is impeded when it reaches the extent of the Arapahoe Sandstone to the north, where it encounters the relatively lower-conductivity weathered bedrock. Slower groundwater flow rates resulted in longer residence times and increased potential for degradation. The reduction of flow rates may be due to the thinning of sandstone in the direction of flow; and

- Increasing ET effects as groundwater nears streams causing lower concentrations at stream areas.

PSA 15 model sensitivity simulations bracketed the range of time-averaged TCE parent and daughter concentrations. The observed concentration distribution of daughter products (cis-1,2-DCE and VC for the PCE degradation chain; chloroform and methylene chloride for the CCl_4 degradation chain) was bracketed by the various sensitivity runs, with high concentrations (producing high daughter products) and low degradation (producing low daughter products) cases for the PCE degradation chain. The results are shown on Figures D-15 and D-16 in Appendix D.

6.2.1.9.5 Transport Model Results – Closure Configuration

Groundwater flow paths determined for present conditions in the PSA 15 model area trend to the north-northeast (towards North Walnut Creek). Groundwater flows in the lower weathered bedrock layers. Changes to the groundwater system due to the proposed closure configuration did not significantly impact the PSA 15 area.

Future transport simulations indicated that the time it takes for TCE to reach steady-state concentrations was approximately 85 years. A total of 16 transport model runs were simulated. All runs were simulated for at least 150 years to

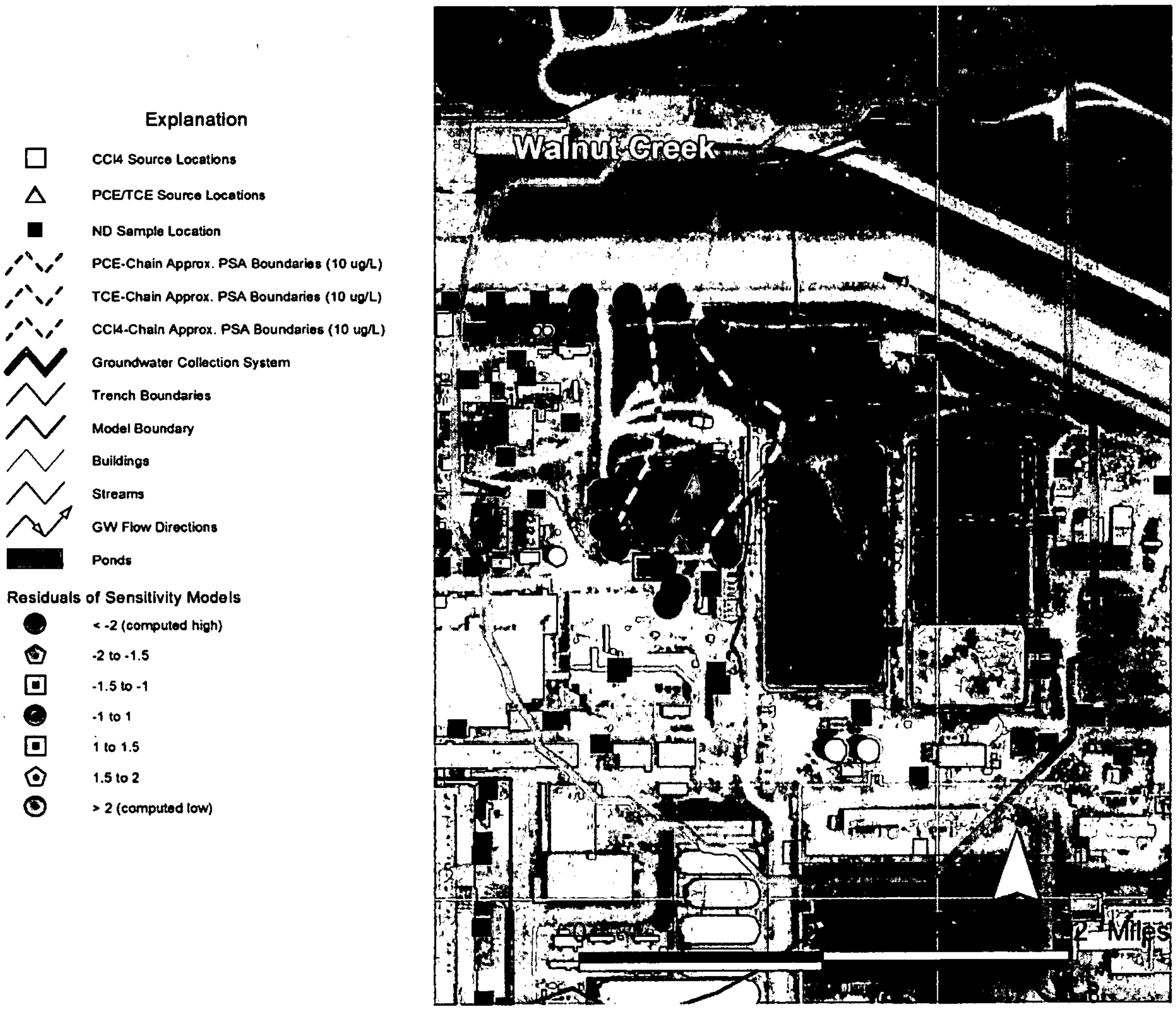

Figure 6.66. PSA 15 – Log residual concentrations. High predicted concentration (TCE) sensitivity run (low degradation).

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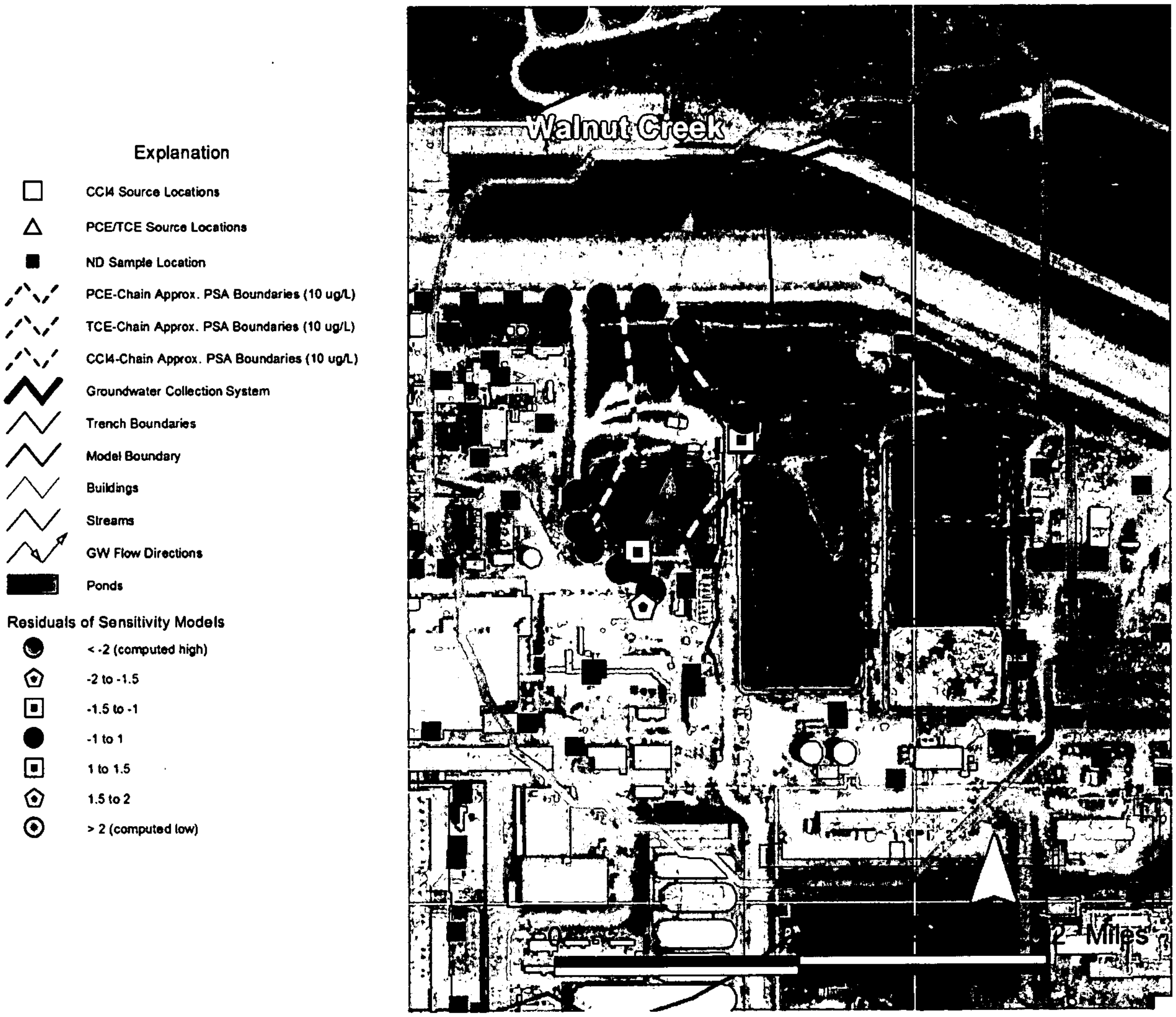

Figure 6.67. PSA 15 – Log residual concentrations. Low predicted concentration (TCE) sensitivity run (high degradation).

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establish steady long-term concentrations with time at the PSA extent along North Walnut Creek to the north. Simulated groundwater concentrations for the 16 model runs for each integrated flow model-predicted discharge location are shown on Figure 6.68.

Future transport simulations indicated that the time it takes for CCl_4 to reach steady-state concentrations was approximately 40 years. A total of 16 transport model runs were produced. All model runs were evaluated for a minimum of 100 years in order to estimate the maximum distance that the plume would travel. Transport flow model-simulated groundwater concentrations for the 16 model runs for selected integrated flow groundwater discharge areas are shown on Figure 6.69.

The bar charts on Figure 6.68 show results for discharge locations that were most impacted by TCE. Concentrations at these locations ranged from non-detect (zero) to approximately 0.01 mg/L down-gradient of the inferred VOC source. None of the long-term simulated sensitivity run concentrations at groundwater discharge locations were above draft surface water PRG levels.

The bar charts on Figure 6.69 show results for discharge locations that have the most potential to be impacted by CCl_4. Concentrations at these locations ranged from non-detect (zero) to approximately 0.3 mg/L down-gradient of the inferred VOC source. Simulated long-term groundwater discharge concentrations of CCl_4 were also below draft surface water PRG levels.

Mass flux from the transport model indicated that the simulated dominant loss mechanism for VOCs was biodegradation (as shown on Figures 6.70 and 6.71).

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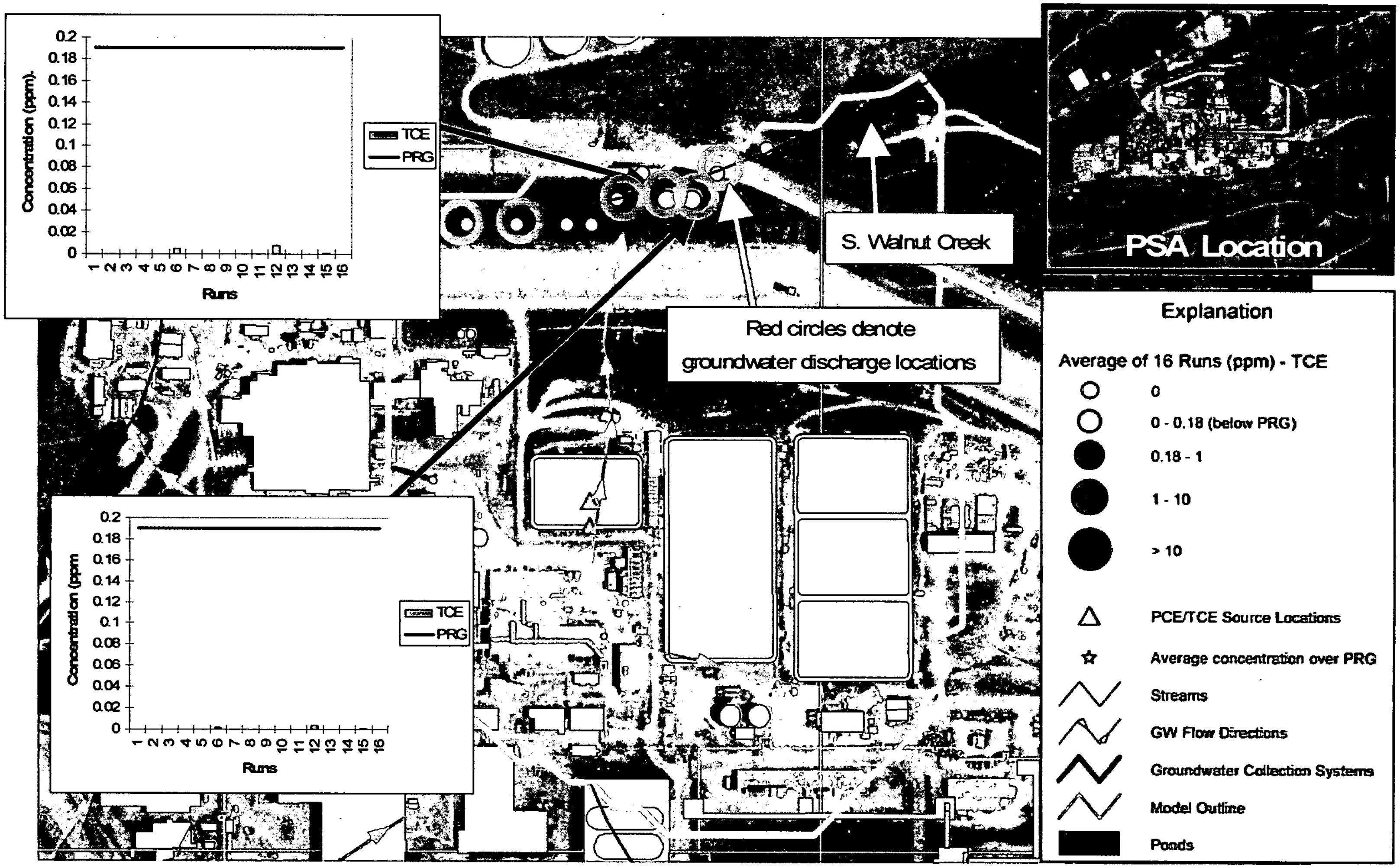

Figure 6.68. PSA 15 - Simulated TCE groundwater concentrations at potential discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

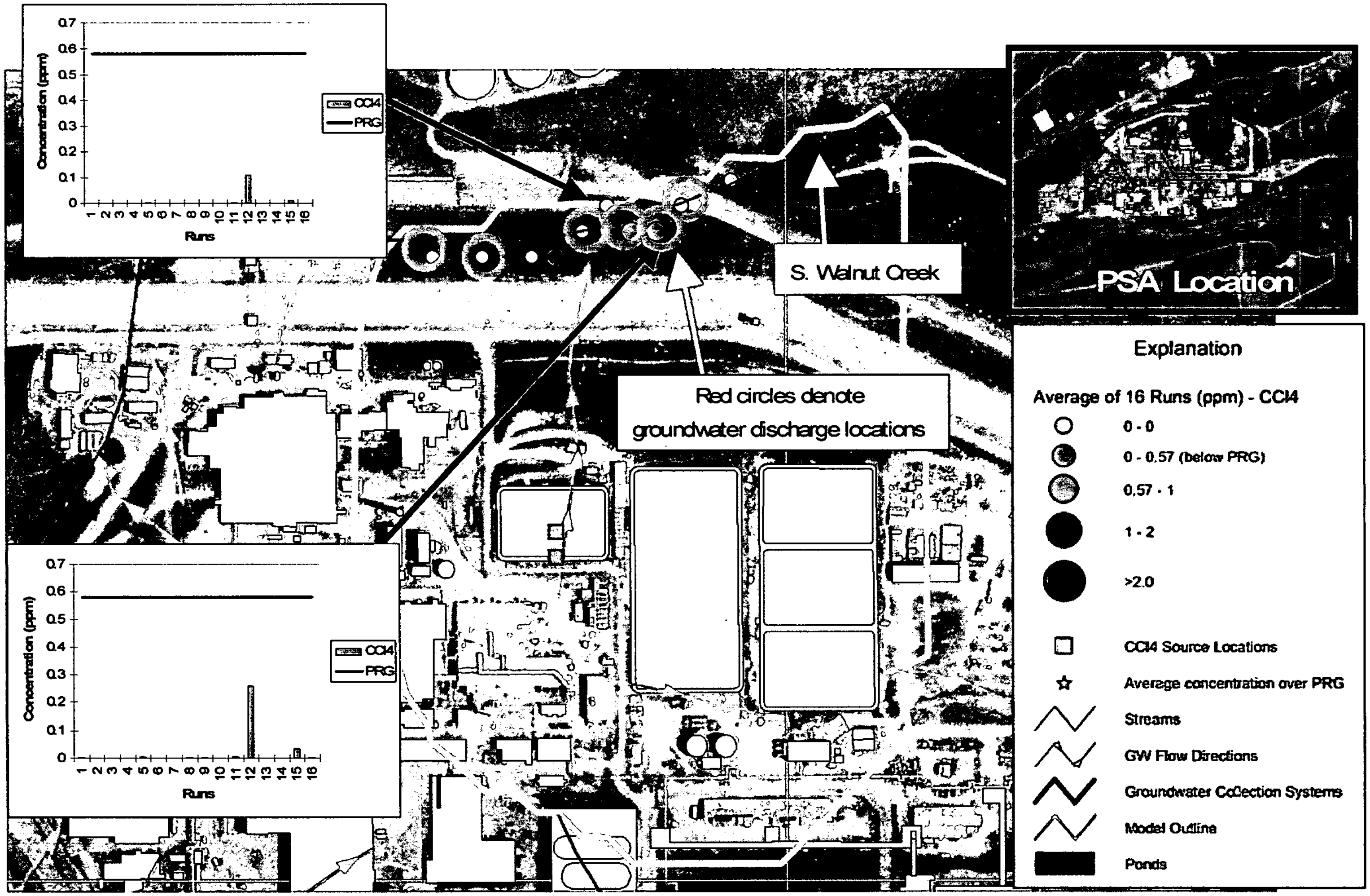

Figure 6.69. PSA 15 - Simulated CCl_4 groundwater concentrations at potential discharge locations. Run 1 used the parameters that best reproduced the time-averaged concentration distribution.

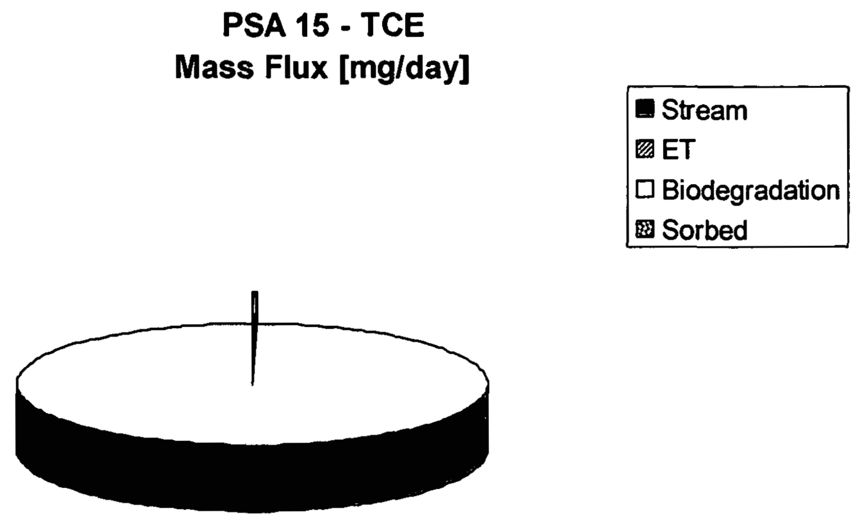

Figure 6.70. PSA 15. Steady-state mass flux for TCE.

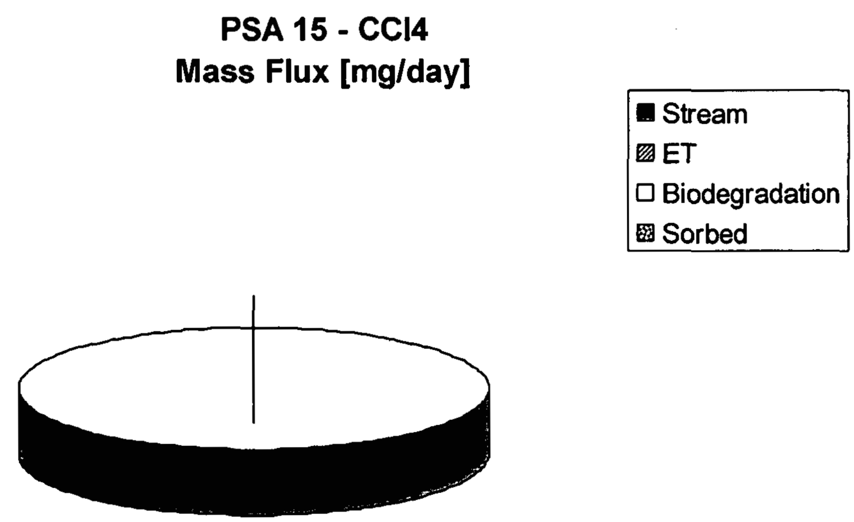

Figure 6.71. PSA 15. Steady-state mass flux for CCl_4.

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6.2.2 Transport Modeling – General Findings

General Findings - Degradation Rates

In general, RT3D simulations indicated that degradation rates at the Site were low relative to the published ranges (Table 6.1). This was reasonable considering that the limited amount of DO data indicated that groundwater over most of the Site was aerobic. The highly chlorinated contaminants (PCE, TCE, and CCl_4) were more likely to degrade under anaerobic conditions by reductive de-halogenation whereas degradation of the lightly chlorinated contaminants (VC) was more likely in aerobic conditions by bio-oxidation (Mercer, et. al., 1998).

The presence of VOC degradation at the Site was likely, based on two main items of evidence. First, nearly all PSAs contain every major daughter product of the degradation chains. Second, cis-1,2-DCE, the primary isomer produced when TCE biodegrades (Mercer, 1998), was present in every PSA being evaluated at a high ratio relative to trans-1,2 DCE. A direct release of 1,2-DCE would normally contain similar amounts of the cis-and trans-isomers.

The degradation rates vary between individual PSAs, but were within a similar range (shown in Table 6.4). Higher rates occur in areas where VOCs were present with petroleum products, which provide a readily available carbon source. Near discharge areas where the groundwater table was shallow, anaerobic degradation can increase by two to three orders of magnitude (Clement, 2003). Along hill slopes, aerobic degradation was probably higher due to the lower water table and lack of paved areas. Unfortunately, there was not adequate spatial information about water chemistry or VOC time-series concentrations define spatial degradation zones within each PSA model.

General Findings – Sorption

The refined range of sorption values (shown in Table 6.5) was generally at the lower end of the range calculated using Site-specific soil parameters. The low sorption values could be compensating for another parameter that affects transport similarly, such as porosity, roughly estimated from 0.03 to 0.3 for all layers and simulations. Increasing the sorption constant has the same effect as increasing porosity, slowing transport, except that the magnitude of the effect was chemical dependent for sorption.

Table 6.4. Range of modeled degradation rates from all PSA models [1/day] (a degradation rate of 0.0019/day is equivalent to a half-life of one year).

Chemical	low	high
PCE	0.0001	0.01
TCE	0.00005	0.005
Cis-1,2-DCE	0.00005	0.01
VC	0.01	0.2
CCl_4	0.0001	0.0006
Chloroform	0.00005	0.002
Methylene chloride	0.00001	0.2

Table 6.5. Range of modeled sorption constants [L/mg].

Chemical	low	high
PCE	0.8×10^{-7}	1.5×10^{-6}
TCE	2.5×10^{-8}	5.0×10^{-6}
Cis-1,2-DCE	1.3×10^{-8}	2.6×10^{-6}
VC	8.0×10^{-10}	8.0×10^{-6}
CCl_4	0.9×10^{-7}	1.8×10^{-6}
Chloroform	0.9×10^{-8}	1.9×10^{-6}
Methylene chloride	1.4×10^{-9}	2.8×10^{-6}

General Findings - Dispersion

In general, dispersivity values between 5 and 20 meters reproduced the observed PSA concentration distributions. This was consistent with contaminant travel distances of 350 meters or less for most of the PSAs. For example, PSA 5, with a travel distance of less than 200 meters, had a modeled dispersivity of 10 meters whereas PSA 2S, with a traveled distance of about 350 meters, had a dispersivity of 15 meters.

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6.2.2.1 Transport Modeling – Closure Configuration

Transport modeling of the closure configuration simulated the movement of known contaminants for the proposed closure configuration. A total of 16 transport simulations were run for PSA 15. Simulations were run until steady contaminant concentrations were obtained at groundwater discharge areas.

Table 6.6 summarizes transport simulations and results for the proposed closure configuration. Simulated groundwater TCE concentrations at discharge locations in PSA 2N, PSA 2S, and PSA 5 model areas were higher than draft PRGs at groundwater discharge areas (shown in bold).

Table 6.6. Summary of closure configuration transport simulations.

PSA	PCE/TCE chain	CCl_4 chain
PSA 2N (6/7)	PCE, **TCE**	CCl_4
PSA 2S	PCE, **TCE**	CCl_4
PSA 5	PCE, **TCE**	Below draft surface water PRG
PSA 9	TCE	CCl_4
PSA 10	TCE	Below draft surface water PRG
PSA 12	TCE	CCl_4
PSA 14	Below draft surface water PRG	CCl_4
PSA 15	TCE	CCl_4

Note: (PSAs with the average concentration of the sensitivity simulations above the draft surface water PRG level at one or more potential discharge cells are shown in bold.)

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7.0 SUMMARY AND CONCLUSIONS

This section summarizes the key steps, results, and conclusions of this study. An approach was developed in this study to construct hydrologic flow and transport models to predict long-term VOC groundwater concentrations at groundwater discharge areas. Major results and key conclusions are described for each modeling step. Only VOCs detected in the IA and the area immediately east (East Trench area, 903 Pad area, and the Mound Groundwater Collection System area) were considered in this report. VOCs detected in the PU&D yard area will be evaluated under separate cover.

Data Analysis

Available geologic, hydrologic, and VOC information were collected and synthesized into a digital database and GIS so that it could be efficiently evaluated for data quantity and quality. The digital database/GIS was also used extensively to develop spatial and temporal interpretations of a substantial database of containing this information. Although much of the geologic and hydrologic data had already been compiled and evaluated in the SWWB modeling (Kaiser-Hill, 2002), they were combined with all historical VOC and geochemical information to identify likely VOC groundwater sources, to define individual plume areas, and to associate the two.

The concept of PSAs was introduced in this evaluation. A PSA refers to distinct subsurface areas within which all sample locations with detectable groundwater VOCs are assumed to be associated with a single, or multiple, indistinguishable groundwater VOC sources (given groundwater flow paths and historical release information). Time-averaged historical VOC sample concentration data provided more data locations and allowed maximum PSA extents to be established with greater spatial constraint. The concept of PSAs was introduced, rather than specifying "plumes", to emphasize the degree of uncertainty involved in uniquely associating well concentrations with sources. Developing multiple PSAs for PCE and CCl_4 compounds and their degradation chains provided valuable information on their fate and transport in groundwater.

Results of detailed analysis of hydrogeologic data and flow conditions, combined with historical release information and VOC groundwater concentration data, resulted in definition of 19 distinct PSAs. Results also indicated that most contaminant sources correlated with known historical contaminant releases. Most historical releases did not result in groundwater VOC sources. Data evaluation also showed that observed VOC concentrations were typically highest near inferred VOC source locations.

Further data analysis suggested that most PSAs probably have already intercepted groundwater discharge areas. Moreover, relatively steady VOC concentrations in time observed at most sample locations suggested that PSAs have probably reached stable configurations, though some areas may still be

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developing (i.e., 903 Pad area). The steady well concentration trends also suggested that VOC sources have probably reached steady concentrations in time. Non-aqueous phase liquid (NAPLs) VOC sources typically produce long-term, steady, dissolved-phase concentrations in groundwater.

Primary VOCs considered in this study were PCE and CCl_4, and their daughter products. Successive daughter products of PCE include TCE, cis-1,2-DCE, and then VC. Successive daughter products of CCl_4 include CCl_3 and then CCl_2. The occurrence of both parent and daughter product VOCs within most PSAs suggested that biodegradation occurs at RFETS, though an independent study suggested rates are variable but low throughout the model area. Additional evidence suggested that TCE occurred as a source in several areas, though it is probably also a degradation product of PCE.

Draft CRA surface water PRGs, which define the relative risks associated with each VOC, were used as the basis for determining whether individual PSAs would be modeled. The total number of PSAs modeled was reduced to nine for PCE, 10 for TCE, and seven for CCl_4.

Important PSA and source characteristics, combined with groundwater flow characteristics, were incorporated into a conceptual groundwater flow and fate and transport model. The conceptual model provided the basis for development of subsequent flow and transport models. In the conceptual model, the fate and transport of VOCs in groundwater at RFETS was described in detail from source areas to discharge areas. Results of flow and transport modeling were used to update and refine the conceptual model.

Modeling showed that three-dimensional groundwater flow is important in supporting a detailed flow and transport model for the Site. Groundwater in upper, flatter mesa areas is generally flows downward, but flows upward near the bottom of hillslopes, or streams (hillslope hydrology). This is an important feature of the conceptual model because slower flow rates from source allow more efficient degradation, mostly within bedrock, before it eventually emerges at stream areas. Because ET dominates near-stream hydraulics, model results indicated increasing amounts of VOCs are lost via ET closer to streams. This is significant because this loss to ET, during warmer months, helps attentuate the VOCs before they have the ability to discharge as baseflow to streams, seeps, ponds, or overland flow.

Current Conditions Simulations

Current integrated flow conditions in the IA were first simulated using a higher resolution numerical grid than the original SWWB modeling (Kaiser-Hill, 2002). The MIKE SHE code was used to simulate the integrated flow conditions. Performance of the model was good, if not better, than the SWWB model because local-scale features were refined using the higher resolution grid.

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Simulated groundwater levels, drain discharges, and stream flows compared well against observed data.

Next, an appropriate groundwater flow and transport code capable of simulating the complex three-dimensional groundwater flows and VOC fate and transport was selected based on specific selection criteria and modeling objectives. The GMS modeling software, developed by the DOD, was selected to simulate groundwater flow and VOC fate and transport at RFETS. Within this code, groundwater flows were modeled with the USGS MODFLOW, and the VOC fate and transport were modeled using the RT3D reactive transport code developed by DOE. Sorption, biodegradation, molecular diffusion, dispersion, and ET loss were simulated by RT3D.

Eight sub-scale MODFLOW groundwater flow models were developed for different sub areas of the Site. Some of these model areas include more than one PSA. Groundwater flow pathway analysis was an important step in identifying groundwater VOC source locations, the number of source locations, and likely source release times. The USGS code MODPATH (particle tracking software) was used in conjunction with the MODFLOW simulations to iteratively evaluate various source assumptions.

Results of the iterative groundwater flow path analysis for eight different model areas, that include at least one PSA each, confirmed initial assumptions about possible VOC source locations, the number of sources, timing of sources, and groundwater pathways and travel velocities. Results showed that it is reasonable to assume sources were introduced into groundwater about 30 to 50 years ago. HRR information supports this conclusion. Flow path analysis resulted in 22 different source areas that could explain concentration distributions in the 19 separate areas.

RT3D reactive transport modeling was conducted to evaluate the fate and transport of VOCs from time of assumed source release to current conditions. A sensitivity analysis was used to determine several things. First, the parameters which most sensitively control the fate and transport of VOCs were identified. Second, realistic ranges of these parameter values were obtained that reproduce time-averaged concentrations. This range effectively represents uncertainty in these model input parameters. Lastly, RT3D sensitivity simulations of current conditions were used to bound the range of effective source concentrations which reproduced time-averaged concentrations. Sensitivity simulations were also used to confirm assumed source depths and locations defined earlier in the MODPATH groundwater flow path analysis.

Several conclusions can be made from the reactive transport sensitivity analysis conducted for each PSA. First, many factors affected the fate and transport of VOCs from source release time to present. Results showed that the hydraulic conductivity, depth where source (mass flux) was introduced, and biodegradation rates influenced fate and transport the most (compared to other factors, such as

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sorption, dispersion, source concentration, diffusion, and porosity). The range of effective source concentrations and source depths, determined through this modeling, reproduced the range of observed time-averaged concentrations within each PSA for both parent and daughter VOCs.

Closure Configuration Simulations

The integrated VOC flow model input was adjusted to simulate the proposed closure land reconfiguration. The proposed closure configuration simulated in this evaluation is different than specified in the SWWB modeling (Kaiser-Hill, 2002) and only included the modeled IA area and areas east. The primary purpose for simulating the the proposed closure configuration with MIKE SHE was to use annual average groundwater levels as initial conditions throughout the GMS MODFLOW model domain and as boundary conditions along the model perimeter. It was also to identify groundwater discharge areas within the integrated VOC flow model boundary.

Discharge frequency and flow rates were calculated by the model only for internal streams. Discharge to streams along model boundaries along North Walnut and Woman Creek, and South Walnut in the B-pond area were not simulated. As a result, results of the original SWWB model were used to assess discharge locations, rates, and frequency.

Simulated closure configuration groundwater flow velocities remain largely unchanged from current configuration because gradients did not change dramatically and are controlled more by the hillslope morphology (surface and bedrock topographies). The largest flow direction changes occurred near buildings with deep foundations where footing drains were deactivated (371, 771, 881, and 991), and along South Walnut Creek east of 991, and where the channel has been re-engineered to eliminate roadways, fenced areas, and associated culverts. Local flow directions near the current Mound Groundwater Collection System changed notably due to this proposed reconfiguration.

Simulated closure scenario groundwater levels increased throughout the model area due to changes in the proposed closure configuration. In some seep areas, groundwater discharged to three of four modified IA streams (drainage between Buildings 371 and 771, the drainage along South Walnut south of Building 991, and in the drainage west of Building 371). Average conditions indicated the discharge occurred only in the drainage between Buildings 371 and 771.

Each PSA steady-state MODFLOW groundwater flow model was updated with the proposed IA configuration modifications and MIKE SHE output. MODPATH was used to estimate simulation times necessary to reach steady travel times. Results showed this was between decades to hundreds of years and accounts for both flow regime adjustments and subsequent VOC transport. In addition, areas where groundwater discharged either to the ground surface (i.e., overland flow) or directly to streams (i.e., baseflow) were computed by the integrated

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MIKE SHE flow model for the closure configuration. They were specified for each PSA model area so that the potential for VOC-impacted water at discharge locations could be assessed.

A total of 16 reactive transport model simulations produced a range of possible long-term concentrations at groundwater discharge areas that reflect the approximate range of uncertainty in key input parameter values which strongly control VOC concentrations. Input model parameters were adjusted over ranges that reproduced the range of observed historical time-averaged VOC concentrations. In other words, some parameter values specified in the 16 simulations probably conservatively over-predict long-term groundwater concentrations at discharge locations, while others may under-predict them. Average concentrations at groundwater discharge areas from all 16 model runs were compared against proposed draft surface water PRG values.

Several conclusions were made based on results of the reactive transport modeling and are summarized below:

- Assuming constant source concentrations with time (conservative), in four of the eight sub-scale PSA models, at least one of the 16 simulations produce long-term groundwater concentrations for TCE, or CCl_4 at groundwater discharge areas that were above the draft surface water PRGs. These PSAs include the following:
  - the East Trenches area,
  - the Mound Groundwater Collection System area,
  - the Building 771 area, and
  - the area southeast of the 903 Pad area (Ryan's Pit area);
- Of these areas, only the Building 771 area showed that the average of long-term simulated groundwater concentrations for the 16 runs were below draft PRGs at groundwater discharge areas.
- Integrated flow modeling showed the following in these areas:
  - in the drainage west of Building 771, groundwater discharged to surface water, even under average climate conditions, due to shallow bedrock and Arapahoe Sandstone in the area;
  - in the South Walnut Creek drainage north and down-gradient of the Mound Groundwater Collection System, discharge occurred in some areas for average conditions, but increased during precipitation events;
  - in the area southeast and down-gradient of the Ryan's Pit area, groundwater discharged to the SID and Woman Creek, only during higher precipitation events, and
  - although actual discharge into the B-pond series north and down-gradient of the East Trench VOC source area was not calculated by

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the model, pond water was derived by local runoff and groundwater inflows.

In general, only parent compounds CCl_4 and TCE were above PRGs at groundwater discharge areas. All other daughter products and PCE did not. For the remainder of PSAs not listed above, simulated groundwater VOC concentrations in groundwater discharge areas for all 16 simulations were below draft surface water PRGs. This is due to a combination of the following:

- slower groundwater velocities in bedrock (generally unconsolidated material becomes unsaturated at the top of hillslopes, but then resaturated close to streams);
- the simultaneous combined effect of attenuation processes (such as biodegradation, sorption, and ET loss) reduced concentrations in groundwater discharge to surface areas.

In most PSAs, the dominant attenuation process appeared to be low rates of biodegradation, though ET loss becomes more significant in the eastern PSAs (i.e., southeast of the 903 Pad area, and in the East Trenches area) as VOCs in near-stream areas. Although, parameter values for each closure configuration model reproduced observed time-averaged concentrations, some combinations underestimated concentrations, while others over-predicted concentrations. The latter case likely over predicted long-term closure concentrations at groundwater discharge areas. As such, a single run should not be considered to be an accurate representation of closure concentrations, or even the most reasonable. Rather, the range of predicted output should be used in assessments.

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
1	1953	Solar Evaporation Ponds	700, 900	E2085000	N751000	Various events leading to loss of nitrate contaminated water to ground surface- leaking ponds, pump house spills, overspray to east from wind	0	0	0	0	0	0	0	0	0	1	Note: very low concentrations (<6 ppb) of TCE, carbon tet, tetrachloroethene and chloroform also found in ITPH spill	unknown but large quantities over many years of operation	large area - all old and new solar ponds and area extending east and north	varied, but one spill at ITPH (Aug 7, 1989) showed 2,200 mg/L NO3-
2	1952	Original Process Waste Lines	000	varies	varies	Known releases in pipelines and tanks transporting or storing process wastes. Certain streams carried VOCs, oil and greases, cleaning compounds.	0	0	0	0	0	0	0	1	1	0	cleaning compounds, VOCs	not specified	not specified	not specified
3	1980	Antifreeze Discharge	000	E2083800	N749985	Antifreeze solution discharged from a chiller unit into a B708 floor drain terminating at an open culvert East of 10th Street and diverted into Pond B-1	0	0	0	0	0	0	0	0	0	0	ethylene glycol	155	not specified	25% ethylene glycol in water
4	1974	Roadway Spraying	000	varies	varies	RFP Roadway Spraying	0	0	0	0	0	0	0	0	1	0	No.2 Diesel	not specified	not specified	not specified
5	1993	Modular Tanks and B910 Treatment System	000	E2085050	N751300	Hazardous waste leaked from temp. Modular Tanks storing liquid collected by the Solar Evaporation Ponds Interceptor Trench System (ITS) to secondary containment. Waste overflowed into pumphouse (secondary containment) and local alarm activated.	0	1	0	1	1	0	0	1	1	1	"F-listed", VOCs, chloroform, methylene chloride, toluene	4700	not specified	TCE=.00302mg/L, CCl4=.00258mg/L, PCE=.00250mg/L, methylene chloride=.00230mg/L, toluene=.00250mg/L, chloroform=.00192mg/L
6	1956	Oil Burn Pit No. 1	300	E2081980	N749857	Oil burned from B444 and B881	0	0	0	0	0	0	0	0	1	0	0	320	not specified	not specified
7	1981	Tank 262 Fuel Oil Spills	300	E2082530	N750730	No. 2 Diesel fuel spilled onto soil	0	0	0	0	0	0	0	0	0	0	No. 2 Diesel fuel	300	one incident reported 1000	not specified
8	1952	Oil Leak	400	E2082185	N749130	Four, No. 6 fuel oil tanks total. Tanks 1-4, one installed in 1967.	0	0	1	0	0	0	0	1	1	0	0	=600+500+50+1700	not specified	not specified
9	1952	Oil Leak	400	E2082185	N749130	1952-1997 Tanks #1-#3 and 1967-1988 Tank #4. No. 6 fuel oil spill supplying to B443 during filling operations and maintenance. Leak in underground transfer line discovered in 1977. Sewage plant recovered 600 gallons of oil.	0	0	1	0	0	0	0	1	0	0	No. 6 fuel oil	500+50+1700	not specified	not specified
10	1957	B444/B453 Drum Storage Area	400	E2082150	N748730	Oil surfaced in July 1983 from high groundwater force. B453 used as oil storage area for many years. Several pools of oil formed. At time, 25 barrels oil awaiting disposal stored outside the building.	0	0	0	0	0	0	0	0	1	0	0	not specified	several pools	not specified
11	1971	Middle Site Chemical Storage	500	E2082950	N749630	Leaks and spills in storage area E of B551. Drums leaking oily substance	0	0	0	0	0	0	0	1	1		acids,soaps, beryllium scrap metal	> 55	not specified	not specified
12	1958	Scrap Metal Sites - 500 Area	500	E2083150	N750100	Possibility that transformers contaminated with PCBs disposed of here	1	0	0	0	0	0	0	0	0	0	scrap metal components	not specified	not specified	not specified
13	1982	Transformer storage Outside B662	600	E2083500	N748900	Cooling oil leaked from the transformer found during inspection	1	0	0	0	0	0	0	0	1	0	cooling oil	not specified	not specified	500 mg/L or greater
14	1982	Transformer Storage outside B662	600	E2083500	N748900	Photo taken in 1982 of transofrmer storage outside B662. Stored in a catch basin until shipped off-Site. In 1986, EPA found transofrmer sotred for reuse leaking	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	PCBs > 500ppm
15	1954	Temporary Waste storage B663	600	E2083000	N749000	Storage activities include oil, still bottoms waste coolent, perclene, solids and gasoline	0	0	0	0	0	0	0	0	1	0	perclene, still bottoms, gasoline	not specified	not specified	not specified
16	1954	Temporary Waste Storage B663	600	E2083000	N749000	Two temporary, wooden buildings constructed on concrete slabs in early 1950s where B662 and B663 located today. Wooden buildings removed prior to 1954. Slabs stored liquid waste including coolant. Drums and boxes from B771 and B774 placed on slabs in 1962. In 1997 two oil stained areas identified in the soil.	0	0	0	0	0	0	0	0	0	0	coolants, liquid wastes, gasoline spills	not specified	not specified	ethylbenzene=43ppm Total Zylene=260ppm 1,1,1-TCA=230ppm 1,2,4-trimethylbenzene=100ppm N-butylbenzene=44ppm Napthalene=61ppm 1,3-dichlorobenzene=25ppm
17	1965	Chemical Storage - South Site (117.3) and Fuel Oil Tank 221 Spills (152)	600	E2082685	N749165	Glovebox leaked oil during disposal onto Central Avenue, ground, fork lift and truck. Glovebox placed on plastic sheeting at 7th St.and Central Ave. Tank 221 leaked No. 6 fuel oil from valves and heater coils.	0	0	0	0	0	0	0	0	1	0	No. 6 fuel oil, benzene, chloroform, trichlorofluoromethane, vinyl chloride	700+400+50	900	benzene = 0.618 mg/kg chloroform = .821 mg/kg vinyl chloride = 0.011 mg/kg
18	1970	Multiple Solvent Spills West of Building 730	700	E2083865	N750715	Leaking underground tank with carbon tetrachloride (also see IHSS 118.2)	0	0	0	0	1	0	0	1	0	0	0	not specified	800	not specified
19	1970	Multiple Solvent Spills West of Building 730	700	E2083865	N750715	Leaking underground tank with carbon tetrachloride (also see IHSS 118.2). Multiple large spills: prior to 1970, 1976, 1981	0	0	0	0	1	0	0	1	0	0	0	up to 1000 gallons in one incident, 200 to 300 in another incident (all before 1970); more of unknown quantity after 1970	800	"raw carbon tetrachloride"

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
20	1981	South End of Building 776 Solvent Spill	700	E2084000	N750000	Carbon tetrachloride tank spill (also see IHSS 118.1)	0	0	0	0	1	0	0	1	0	0	0	not specified	not specified	not specified
21	1958	Oil Sludge Pit	800	E2084169	N747740	Oil sludge from tank cleanouts	0	0	0	0	0	0	0	0	1	0	0	2200	2800	not specified
22	unknown	Chemical Burial	800	E2084159	N748113	Area south of B881 reportedly used to bury unknown chemicals.	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified	not specified
23	unknown	Liquid Dumping	800	E2084395	N7486385	CEARP Phase I report indicates area East of B881 used for disposal of unknown liquids and drums.	0	0	0	0	0	0	0	0	0	0	PAHs specified	not specified	not specified	not specified
24	1973	Building 881 Hillside Oil Leak	800	E2083938	N747808	Oil discovered flowing on slope S. of 881	0	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
25	1973	B881 Hillside Oil Leak	800	E2083938	N747808	Oil discovered flowing from slope south of B881 (later found to be the footing drain from B881).	0	1	0	1	0	0	0	1	1	0	VOCs, oils, solvents, unknown chemicals	not specified	not specified	PCE=128ppb, TCE=14ppb (both samples from North end of skimming pond)
26	1988	Transformer 881-4	800	E2084000	N749000	PCB-contaminated transformer oil leak onto concrete pad	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	110 ppm PCBs
27	1954	Trench T-1	900	E2086046	N749461	Drum burial area (approx. 170 drums)	0	0	0	0	0	0	0	0	0	0	chemical materials	not specified	3750	not specified
28	1954	Trench T-1	900	E2086046	N749461	Drum burial area (170 drums) between November 1954 and December 1962. Contents included rads metals and organics, but quantities of organic and types poorly defined. Trench remediated in 1998 by removal of drums.	0	0	0	0	0	0	0	1	1	0	0	not specified	3750	not specified
29	1954	Trench T-1	900	E2086046	N749461	Drum burial area (approx. 170 drums)	0	0	0	0	0	0	0	0	0	0	chemical materials	not specified	3750	not specified
30	1954	Trench T-2	900	E2085885	N748569	Waste burial area	0	0	0	0	0	0	0	0	0	0	chemical materials	not specified	not specified	not specified
31	1969	Ryan's Pit (Trench T-2)	900	E2085885	N748569	Site involved solvent disposal, other chemicals/materials, paint thinners	0	1	0	1	1	0	0	1	1	0	solvents, paint thinners, construction chemicals/materials	not specified	not specified	not specified
32	1969	Trench T-2 (a.k.a. Ryan's Pit)	900	E2085885	N748569	Area primarily used for disposal of solvents, paint thinners, diesel fuel, and other construction related chemicals/materials.	0	1	1	1	0	0	0	1	0	0	VOCs, xylene, toluene, ethylbenzene	not specified	not specified	not specified
33	1969	Trench T-2 (Ryan's Pit)	900	E2085885	N748569	Trench primarily used for disposal of solvents, paint thinners, diesel fuel and other construciton related chemicals/materials.	0	1	1	1	1	0	0	1	0	0	xylene, toluene, ethylbenzene, paint thinner, diesel fuel	unknown	not specified	not specified
34	1958	903 Pad	900	E2086000	N749000	Leaking drums with waste oil	0	1	0	1	1	0	0	1	1	0	0	2750	not specified	not specified
35	1954	Mound Area	900	E2086086	N749586	Drum burial in shallow trench	0	0	1	0	1	0	0	1	1	0	0	7700	928	not specified
36	1954	Mound Area	900	E2086086	N749586	Mounding contaminated combustibles from B444. Drums contained pinhole leaks. Later, drums from B444, B869, B883, B771, B776 placed in Mound area. In 1959, burning of oil became acceptable and mounding discontinued.	0	1	0	1	0	0	0	1	1	0	U-contaminated oil, organic liquid wastes, solvents	unknown amount	86500	PCE before excav.=86000ug/kg, TCE before excav.=900ug/kg, PCE after excav.=630ug/kg, TCE after excav.=630ug/kg
37	1994	OU2 Water Spill	900	E2086346	N750163	As a result of separation of primary and secondary piping with OU2 collection system, surface water containing hazardous substances released to environment (soil) from influent pipe system from Walnut Creek to OU2 treatment system.	0	1	1	1	1	0	1	1	1	0	chloroform, toluene, "F001 List"	200 (visual determination)	not specified	PCE soil samples<PQLs
38	1957	Oil Burn Pit No. 2	900	E2085927	N749533	Dumped drums of oil into open pit for burning	0	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
39	1964	903 Lip Area	900	E2086000	N749000	contaminated surface soils attributed to storm and wind dispersion from the 903 Pad Drum Storage Area with possible contributions from historical fires and stack effluent	0	0	0	0	0	0	0	0	0	0	VOCs	unknown	unknown	unknown
40	1957	Oil Burn Pit No. 2	900	E2085927	N749533	in 1957 through 1961 (total of at least 1354 drums) drums of coolant, still bottoms, and waste oil were burned in an open pit and groundwater and incidental storm events routinely entered the burn pit and would become contaminated	0	0	0	0	0	0	0	0	1	0	coolant, still bottoms and waste oils	unknown	unknown	unknown
41	1954	Mound Site Plume	900	E2086109	N750108	Drums were mounded at this location between August 1954 and Sept 1958. Waste contained oils and solvents. All drums were removed by May 1970. Source removal efforts involved removal, treatment, and replacement between March and September 1997. In Situ treatment system installed in 1998 to treat organics.	0	0	0	0	0	0	0	1	1	0	0	not specified	not specified	not specified
42	1986	Diesel Fuel Leak - Building 460	400	E2081800	N748400	100 to 150 gallons of diesel fuel leaked from tanker truck to drainage excavation site south of building 460 (August 3)	0	0	0	0	0	0	0	0	0	0	diesel fuel	150	not specified	not specified

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type PCB	TCE	TCA	PCE	CCl_4	$CHCl_3$	DCE	solvent	oil/grease	nitrates	Other	Volume (gallons)	Area (ft^2)	Concentration
43	1964	Trench T-3	NE	E2086915	N749810	T-3 used primarily for sanitary wastewater and plant sludge. Trench ~10' deep with 2' of soil cover. T-3 also had miscellaneous waste disposed, crushed drums, alphalt planking and construction debris	0	0	0	0	0	0	0	0	0	0	VOCs	not specified	not specified	In 1996, CCl_4=1 8ppm, PCE=0.74-6.3ppm
44	1965	Trench T-4	NE	E2087233	N749840	T-4 used primarily for sanitary wastewater and plant sludge. Trench ~10' deep with 2' of soil cover. T-4 also had miscellaneous waste disposed, crushed drums, alphalt planking and construction debris. T-4 was an addition to T-3	0	0	0	0	0	0	0	0	0	0	VOCs	not specified	11325	PCE=10ppm, TCE=22ppm
45	1954	Trenches T-12 and T-13, East Trenches	NE	E2087100	N749550	Incorporated into RI OU2. Trenches primarily used for disposal of sanitary wastewater treatment plant sludges. Flattened drums and lathe coolant from B444 disposed in trenches.	0	0	0	0	0	0	0	0	1	0	lathe coolants	2400+	not specified, 10' deep	not specified
46	1953	B-Series Drainage Ponds (B-1, B-2, B-3, B-4, B-5)	NE	E2086975	N750430	25% Ethylene glycol (antifreeze) discharged to ponds.	0	0	0	0	0	0	0	0	0	0	antifreeze	155+	not specified	not specified
47	1952	B881	800	E2083850	N748300	Enriched U factory from 1953-1968, stainless steel opeations 1968-1984 and recent waste characterization activities.	1	1	1	1	1	0	0	1	1	1	Shell Vitrea oil, uranyl nitrate, coolant, nitric acid, paint thinners, acetylene	not specified	not specified	not specified
48	1952	B991	900	E2085450	N749900	Historic operations (Pre-1989) and recent operations. Pre-1989, B991 shipping, receiving and final assembly. Components from Hanford and Oak Ridge assembled into final products, inspected and tested and placed in storage for off-Site transport. Room 155 used to determine alternative solvents to replace CCl_4.	1	1	0	0	0	0	0	1	1	1	acetone, nitric acid, alcohol, cutting oils	not specified	not specified	not specified
49	1953	B771	700	E2083800	N751000	Primary facility for Pu operations. After 1957, B771 focused primarily on Pu recovery. Processes involved casting, machining, coating, testing, recovery, storage, and laboratory operations.	0	0	0	0	0	0	0	1	1	1	H_2O_2, alcohol, nitric acid, hydrofluorinated compounds, calcination, thiocyanate	not specified	not specified	not specified
50	1955	B447	400	E2082150	N748550	Anneal depleted uranium parts in heat treatment furnaces. Chip roaster. Drum cleaning and low-level waste packaging and handling.	0	0	1	0	0	0	0	1	1	1	cooling oils, solvents, TrimSol, Freon 113, Mariko detergent, Oakite cleaner, bleach, lathe and milling machine cleaning	not specified	not specified	not specified
51	1957	B776 and B777	700	E2083800, E2084025	N750450, N750450	Pu foundry (B776), fabrication (B776) and assembly operations (B777).	1	1	1	0	1	0	0	1	1	0	Freon113, machine oils and coolants	not specified	not specified	not specified
52	1957	B883	800	E2083825	N748900	1957-1989 is the period of historic operations. Recent operations have occurred since Pu production shut down in 1989.	1	1	0	1	0	0	0	1	1	0	nitric acid, chlorofluorocarbons (CFC)s, oils, Dow Corning 550, TrimSol, mariko, De-Solv-it, Oakite, Ox-Out, ethylene glycol, paints	not specified	not specified	not specified
53	1968	*B371 and in same complex B374, B373, B381*	300	E2082250	N750500	*Assumed B771 and B776 plutonium recovery operations for handling, safety and storage*	0	0	0	0	0	0	0	1	1	0	*acetylene, Isopar-L*	not specified	not specified	not specified
54	1970	B707	700	E2083900	N750000	Constructed to support production of Part V weapons design not fully accommodated by B776 or B777. As a result of the 1969 fire, in B776 and B777, B707 acquired additional plutonium foundry, casting and machining functions.	0	1	1	0	1	0	0	1	1	0	Freon 113, TCA and machining oil primarily. CCl_4 feed to building remains.	not specified	not specified	not specified
55	1984	B460	400	E2081800	N748700	Production of non-nuclear weapon components. Stainless steel manufacturing.	0	1	1	0	1	0	0	1	1	1	chlorinated solvents, TrimSol, Das Cool-521, Dykem Remover and Thinner, machine cutting oil and coolant, alcohols and commercial cleaners, methylene chloride, toluene, acetone, Norpar 12	not specified	not specified	not specified
56	1992	Interceptor Trench Water	900	E2085220	N750900	The transfer line from the central sump to the 207B North Solar Pond separated at the berm allowing release of water down east slope of berm outside the pond. F001 hazardous constituents included in the mixture.	0	0	1	1	1	0	1	1	0	0	"F001" listed contaminants	490	not specified	not specified
57	1951	B444	400	E2082300	N748750	Depleted Uranium machining	0	0	1	1	0	0	0	1	0	0	Cimcool, lathe coolant, various solvents	not specified	not specified	not specified
58	1968	Present Landfill	NW	E2083000	N752500	includes polychlorinated byphenyls (PCBs), paint, solvents, filters with hazardous constituents, hydraulic oil	1	0	0	0	0	0	0	0	1	0	0	total not specified, one incident of 700 gal No.6 fuel oil	2604000	not specified
59	1968	Present Landfill	NW	E2083000	N752500	includes polychlorinated byphenyls (PCBs), paint, solvents, filters with hazardous constituents, hydraulic oil, soil contaminated with #6 fuel oil	1	0	0	0	0	0	0	0	1	0	1	total not specified, one incident of 700 gal No.6 fuel oil	2604000	not specified
60	1974	PU&D Drum Storage Facility	NW	E2081830, E2082035	N751560, N751740	A dumpster containing scrap metal (coated with freon-based or oil-based lathe coolant) and drums containing waste oil were stored in this area. The dumpster is known to have leaked oil to the soil following rain events. Stained soils were found in both areas. In May 1982, one drum was found to have exploded with the bottom blown out. Groundwater and soil sampling indicate some VOC contamination but not a specific source.	0	0	0	1	0	0	0	1	1	0	methylene chloride; freon-based coolant	unknown	eastern third of yard	in GW sample (PCE 1700 ppb, Trichlorofluoroethane 40 ppb); in soil PCE 5700 ppb @ 11 ft
61	1974	PU&D Dumpster Storage Facility	NW	E2081830, E2082035	N751560, N751740	A dumpster containing scrap metal (coated with freon-based or oil-based lathe coolant) and drums containing waste oil were stored in this area. The dumpster is known to have leaked oil to the soil following rain events. Stained soils were found in both areas. In May 1982, one drum was found to have exploded with the bottom blown out. Groundwater and soil sampling indicate some VOC contamination but not a specific source.	0	0	0	1	0	0	0	1	1	0	methylene chloride; freon-based coolant	unknown	eastern third of yard	in GW sample (PCE 1700 ppb; Trichlorofluoroethane 40 ppb); in soil PCE 5700 ppb @ 11 ft
62	1952	*Original Process Waste Lines*	*000*	*varies*	*varies*	*Original Process Waste Lines (OPWL)*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	1	1	1	VOCs, oils, solvents, misc. *laboratory wastes*	*not specified*	not specified	not specified

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
63	1953	Solar Evaporation Ponds	000	E2085000	N751000	Interceptor Trench Pump House System (ITPH)	0	1	0	1	1	0	0	1	1	1	0	refers to construction drawings	refers to construction drawings	1989 analysis listed
64	1982	West Spray Field	000	E2078000	N749000	West Spray Field	0	0	0	0	0	0	0	0	0	1	trace VOCs	190 inches per unit area for 4 years of operation	609840	not specified
65	1982	West Spray Field	000	E2078000	N749000	West Spray Field	0	0	0	0	0	0	0	0	0	1	VOCs, SVOCs	approx. 66 million gal from Solar Evap Ponds sprayed at OU11	not specified	not specified
66	1968	Central Avenue Waste Spill	000	E2084100	N749315	903 Drum Storage Area to B774 West Dock via Central Avenue and Sixth Street	0	0	0	0	1	0	0	1	1	0	lathe coolant = 70% oil and 30% CCl_4	not specified	uncertain, may be approximated	not specified
67	1952	Sanitary Sewer System	000	varies	varies	RFP Main Production Facility. Sanitary Sewer System includes drains, sinks, sumps, latrines to transport, store and treat sanitary waste	0	0	0	0	0	0	0	1	1	1	misc. waste chemicals, laboratory wastes	not specified	not specified	not specified
68	1984	New Process Waste Lines	varies	varies	varies	RFP Main Production Facility (network of underground pipelines and tanks that transport liquid waste streams to B374 Waste Treatment Operations.	1	0	0	0	0	0	0	1	1	1	nitric acid, hydrofluoric acid, hydrochloric acid	not specified	not specified	unknown
69	1952	Storm Drains	varies	varies	varies	239 storm drains at RFETS from roads, parking lots, including footing drains from site buildings.	1	0	0	0	0	0	0	1	1	1	0	not specified	not specified	unknown
70	1953	Waste Leaks	100	E2081755	N749117	a.k.a. Waste Spills	0	0	0	0	0	0	0	0	0	1	liquid process wastes from laboratory in B123	not specified	not specified	not specified
71	1989	B115 Hydraulic Oil Spill	100	E2081500	N749500	Forklift hydraulic line rupture.	0	0	0	0	0	0	0	0	1	0	0	2	not specified	not specified
72	1989	B125 TCE Spill	100	E2081500	N748890	South Dock of B125 - from faulty valve on supply drum	0	1	0	0	0	0	0	1	0	0	0	0.0625	not specified	not specified
73	1954	B111 Transformer PCB Leak	100	E2081500	N749500	Documented leaking ontol secondary containment filled with gravel.	1	0	0	0	0	0	0	0	1	0	0	unknown	unknown	unknown
74	1984	B111 Transformer PCB Leak	100	E2081500	N749500	Large transformer inside B111 basement	1	0	0	0	0	0	0	0	0	0	0	part of 500 gal cooling oil transformer	-	not specified
75	1989	B131 Transformer Leak	100	E2080500	N749000	Electric transformer North of B131 leaked dielectric fluid (cooling oil) onto ground	1	0	0	0	0	0	0	0	0	0	0	0.25	not specified	19ppm, 0.0006 lbs of PCBs
76	1980	B121 Security Incinerator	100	E2081400	N749250	NCR paper containing up to 10-20% PCBs were burned	1	0	0	0	0	0	0	0	0	0	dioxins, furans	not specified	not specified	"tons" of NCR paper
77	1963	Metal Disposal Site North Area and Reactive Metal Destruction Site South Area	300	E2081980, E2081985	N749866, N749486	North of B331 now covered by Sage Ave., and L-shape of B331, site drainage affected by B371 and B375	0	0	0	0	0	0	0	1	0	0	0	not specified	various sizes described	not specified
78	1981	Tank 262 Fuel Oil Spills	300	E2082530	N750730	No. 2 diesel fuel spilled on ground and concrete	0	0	0	0	0	0	0	0	0	0	No. 2 diesel fuel	Four Spills=198+50+20+32	400 yd³ soil affected	not specified
79	1969	Solvent Burning Ground	300	E2082000	N749800	Used for Fire Department Training	0	0	0	0	0	0	0	1	1	0	0	not specified	not specified	not specified
80	1984	Building 334 Cargo Container Area	300	E2082525	N749745	Wastes stored in container included machine oils, solvents, machine coolants and possible low-level radioactive wastes (Summer 1984 - July 1986)	0	0	0	0	0	0	0	1	1	0	machine coolants	none	none	not specified
81	1980	B371 Drum Storage, Unit 63	300	E2082235	N750390	Storage area	0	0	1	0	1	0	0	1	0	0	0	not specified	not specified	not specified
82	1970	Building 331 North Area	300	E2082000	N749600	Preheated road oil vapors in tar trailer ignited when contacted hot burners. Hot oil was to be used on roads. Oil vapors and residual burned road oil were released.	0	0	0	0	0	0	0	0	1	0	oil vapors	not specified	not specified	not specified
83	1991	Transformers North of B371	300	E2082500	N750710	Soil samples north of B371	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	1991 soil samples PCBs > 50ppm for 3/20 samples collected; 1995 soil samples PCBs < 10ppm, concrete PCBs < 1.3ppm
84	-	Transformers North of B371	300	E2082500	N750710	No specific leak documented, however one reference noted one room had potential to be contaminated by transformer spill or fire. Staining on pad beneath valve present. (Dates are Unknown - Present)	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
85	1975	Transformer Leak - 334-1	300	E2082495	N749825	Transformer on concrete pad surrounded by concrete berm northwest of B334 leaked dielectric fluid (772ppb in 1986). Soil samples collected in 1991 show PCBs < 25ppb.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	In 1991, PCB soil samples < 200ppb
86	1991	Gasoline spill North of B331	300	E2081895	N7495750	2-Gallons unleaded gasoline spilled from truck	0	0	0	0	0	0	0	0	0	0	gasoline	2	not specified	not specified
87	1994	Laundry Waste Water Spill from Tank T-803, North of B374	300	E2082500	N750675	Level indicated controller failed allowing liquids to accumulate until pressure ruptured and sprayed dirt road and secondary berm.	0	0	0	0	0	0	0	1	1	0	"F-listed" VOCs	50	10 x 12	data summarized for a VOC suite
88	1953	South Loading Dock	400	E2082398	N748580	Chlorinated hydrocarbon solvents dumped on ground outside Room 106 which opens to dock. Perclene still bottoms and nitric acid stored on dock leaked.	0	0	0	0	0	0	0	1	0	0	perclene still bottoms and nitric acid	solvents not specified, 55-gal drum of bottoms and nitric acid	not specified	Soil samples taken at 2-4 inches indicated 350-1000 mg of Be per g of soil. Normal are 0.01-2 mg per g of soil
89	1952	Underground Concrete Tanks	400	E2081905	N749055	Two tanks total. Tanks process waste from B441 and B123. One tank originally 60ft south of B441, but tank walls may been removed to accommodate construction of B441 addition. Constructed over 7.5ft span of tank. Second tank underground directly outside B441.	0	0	0	0	0	0	0	0	0	1	0	One overflow noted as 1200 gallons	not specified	not specified
90	1953	Radioactive Site North Area	400	E2082300	N749200	Chemical materials contributed to contamination around the building and in B442 ditches	0	0	0	0	0	0	0	0	0	0	chemical materials	not specified	not specified	not specified

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type PCB	TCE	TCA	PCE	CCl_4	$CHCl_3$	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft^2)	Concentration
91	1953	Radioactive Site South Area	400	E2082300	N748700	B439 and B440 possible infiltration of hydraulic oil and CCl_4 originating from U machine tool storage area. B444 area contamination materials include chlorinated hydrocarbon solvents, hydraulic oil and CCl_4.	0	0	0	0	1	0	0	1	1	0	0	not specified	not specified	not specified
92	1956	Original Uranium Chip Roaster	400	E2082050	N748550	Thermal treatment of hazardous waste consisting of depleted U chips coast with freon and TCE.	0	1	0	0	0	0	0	1	0	0	freon (TF)	not specified	not specified	not specified
93	1956	Original Uranium Chip Roaster	400	E2082050	N748550	Uranium chips coated with oil and coolant and TCE. Fire occurred and sprinkling system was set off.	0	1	0	0	0	0	0	1	1	0	coolants	not specified	not specified	not specified
94	1987	Transformer 443-1	400	E2082000	N749500	Transformer 443-1 was known to have leaked and was replaced in 1987 and surrounded with two concrete berms. It is not clear in the text, but it seems the new transformer was also found to have leaked and was removed.	1	0	0	0	0	0	0	0	1	0	0	unknown	not specified, but implied small	Dielectric Fluid with 10,964 ppm PCB
95	-	Transformer 443-1	400	E2082000	N749500	Smears taken from top and bottom valves, level gage and bushings compartment	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	10964 ppm
96	-	Transformer, Roof of B447	400	E2082265	N748530	Believed to have leaked prior to removal. Contaminated runoff from downspouts infiltrated soils adjacent to B447. A storm drain 20ft from B447 may have been contaminated also	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	120 mg and 194 mg
97	1955	Storage Area, South of B334	400	E2082550	N749350	Drums stored on slab contain depleted U chips immersed in oil. Drums leaked and contaminated slabs. 10-20 drums leaking, 30-gallon drum overturned on slab.	0	0	0	1	0	0	0	1	1	0	0	not specified	not specified	One measurement showed slab at 537 dpm. Equipment moved and slab smears are 10,000 dpm.
98	1972	Miscellaneous Dumping, B446 Storm Drain	400	E2082288	N748945	Worker on B444 roof dumping of silver paint and other materials including oil and aluminum paint down B446 storm drain flowed along open ditch south of Cottonwood Ave. to south of fuel oil sotrage tanks then ran northeast to the extent of 7th Ave.	0	0	0	0	0	0	0	0	1	0	paint	not specified	not specified	not specified
99	1990	B443 Tank No. 9 Leak	400	E2082180	N749045	Tightness tests on tanks within RFP, tank No. 9 near steam plant indicated filler pipe leak. Fuel found around filler pipe area.	0	0	0	0	0	0	0	0	0	0	fuel	not specified	not specified	not specified
100	1989	Catalyst Spill, B440	400	E2082050	N748375	5-gallon catalyst leaked from production tank north of B440 to pavemnet and stopped before entered into storm drain. Leak due to crack in tygon tubing.	0	0	0	0	0	0	0	0	0	0	polymethylene polyphenylisocyanate	5	not specified	not specified
101	1991	Vacuum Pump Leak, B442	400	E2082300	N749255	North side of B442, one quart of oil contaminated area beneath pump	0	1	0	0	0	0	1	1	1	0	toluene, benzene, chlorobenzene	0.25	3	above detection limits
102	1991	Oil Leak, 446 Guard Post	400	E2082290	N748915	Motor oil release in motorcycle parking lot north of 446 Guard Post	0	0	0	0	0	0	0	0	1	0	motor oil	0.25	not specified	not specified
103	1992	Transformer 443-2	400	E2082000	N749500	Transformer was observed leaking during and inspection in April 1992. Area was surrounded by a concrete berm once discovered. Excavation was eventually performed to cleanup the area.	1	0	0	0	0	0	0	0	1	0	0	unknown	not specified, but implied small	Dielectric Fluid with 12,000 ppm PCB
104	1993	RCRA Unit #WMU 40.09, Tank T-2 in B460	400	E2081817	N748918	25-gallons material released to pavement, soil and dock area.	0	0	0	0	0	0	0	0	0	0	unknown	25	not specified	not specified
105	1986	Transformer Leak - 515/516	500	E2083000	N750500	Transformer leak	1	0	0	0	0	0	0	0	0	0	0	not specified	9	50-500 ppm
106	1986	Transformer Leak - 515/516	500	E2083000	N750500	PCB-contaminated oil leaking onto underlying soil. 1986 photo shows staining on concrete pad beneath Transformer 516 drain valve.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	1985 samples PCBs 65 ppm, 1992 samples PCBs 3ppm
107	1986	Transformer Leak	500	E2083000	N749500	Transformer 555 leaking again	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	55
108	1986	Substation 555/558 Transformer Leak	500	E2083000	N749500	555 - One of two large transformers making up Substation 555/558 located near 7th and Central Ave	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	PCBs = 4 ppm identified
109	1987	Transformer Leak - 559	500	E2084500	N750000	Transformer 559-1 E side of B559	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
110	1987	Transformer Leak - 559-1	500	E2084500	N750000	East of B559, leaked oil containing PCBs from a faulty valve prior to relocation and retrofitting in 1987.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	Fluid > 500,000ppm, 1991 near concrete pad 190ppm
111	1988	RCRA Storage Unit #1	500	E2083000	N749500	PCBs released into a cargo container, secondary containment pan	1	0	0	0	0	0	0	0	1	0	TRIMSOL lubricant	< 4 oz PCBs and 40 gal lubricant mixed with oil	not specified	59-63 ppm PCBs
112	1986	Transofrmer Leak - 223-1/223-2	500	E2083000	N750000	Transformer oil leak N of B549	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	oil: 50 and 500 ppm (223-1 and 223-2) SEE COMMENTS
113	1986	Substation 555/558 Transformer Leak	500	E2083000	N749500	558 - North side of switchgear building connecting the two transformers. Transformer 558 primary area of contamination. West of Transformer 558 pad, high levels in soil samples	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	PCBs = 480 ppm identified
114	1993	Asphalt Surface near B559	500	E2083500	N750100	F001 waste water spilled from hose used to extract excess water from tanker after tanker water off-loaded into drums. Hose leaked as it was being transferred back to storage	0	1	1	1	1	0	1	1	0	0	F001 water	1	not specified	CCl_4=245ppb, DCE=48ppb, TCE=178ppb
115	1994	Tanker Truck Release of Hazardous Waste from Tank 231B	500	E2083000	N750000	"F-listed" waste spilled from truck during a transfer from Tank 231B. Sludge and liquid released at this same location.	0	0	0	0	0	0	0	1	1	1	"F-listed"	4gallons + .5lbs	not specified	not specified
116	1995	Oil released from air compressor	500	E2083000	N750000	Air compressor ejector vest plugged resulting in compressor oil release. Approx. 15-gal stayed in building, 1-gallon sprayed rocked area outside and 1-gallon went into floor drain	0	0	0	0	0	0	0	0	1	0	compressor oil	16	180	not specified
117	-	Transformer Storage - West of B666	600	E2083000	N748500	Unused and unusable transformers stored on concrete pad west of B666	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
118	-	Transformer Storage - West of B666	600	E2083000	N748500	Unused and unusable transformers stored on concrete pad west of B666	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
119	unknown	Transformer Storage - West of B666	600	E2083000	N748500	Unused and unusable transformers sotred and dismantled for spare parts on concrete pad west of B666. Leaks and spills have occurred according to employees	1	0	0	0	0	0	0	0	1	0	transformer oil	not specified	not specified	Soil PCBs < 1.8ppm in 1996
120	-	Transformers North and South of 661-675 Substation	600	E2083000	N749000	Transformer leaking or has leaked on concrete pad surrounded by rock	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
121	-	Transformers North and South of 661-675 Substation	600	E2083000	N749000	Transformer leaking or has leaked on concrete pad surrounded by rock	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
122	unknown	Transformers North and South of 661/675 Substation	600	E2083000	N749000	Leaking valve discovered on north side of Transofrmer 661-1 on concrete pad (no berm). Transformer 675-1, no documentation of leak, but possible leakage has occurred on concrete pad (no berm).	1	0	0	0	0	0	0	0	1	0	dielectric oil	not specified	not specified	1985 results, PCBs 5-61ppm; 1996 results, PCBs < 25ppm

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/ grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
123	1972	Fiberglassing Areas North(120.1) and West(120.2) of B664	600	E2082750, E2082650	N748550, N748400	Residue soils near B664 as a result of packaging activities	0	0	0	0	0	0	0	1	0	0	resin, catalyst materials	not specified	not specified	not specified
124	1959	Radioactive Site - B444 Parking Lot	600	E2083000	N748700	Oils and Coolants stored in storage area in great quantity leaked	0	0	0	0	0	0	0	1	1	0	Coolants	not specified	1000 for one of incidents	not specified
125	1971	Storage Site West of B664	600	E2082500	N748000	Forklift leaked hydraulic oil outside B664 on asphalt	0	0	0	0	0	0	0	0	1	0	Hydraulic oil	not specified	not specified	not specified
126	1986	Transformer Leak - 776-4	700	E2083500	N750500	Leaking transformer with PCBs	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
127	1986	Transformer Leak - 776-4	700	E2083500	N750500	Employee reported leaking from Transformer 776-4, 100-feet West of northwest corner of B776. 1986 photo indicated staining visible on concrete pad	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	Concrete pad PCBs= 498 ug/cm². Soil at South edge of pad PCBs=14,900 ppm
128	1986	Transformer Leak 776-4	700	E2083500	N750500	Located West of B776, transformer pad positioned on an incline with drainage toward an access road, reported leaking on radiator, gauges, valves and bushing. Oily film on most of transformer and concrete pad	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	In 1985, oils>500ppm, concrete pad=498ug/cm². South edge of pad in soil=14,900ppm
129	1986	Transformer Leak - 776-4	700	E2083500	N750500	Leaking transformer with PCBs	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
130	1986	Leaking Transformers - Bldg 707	700	E2084000	N750000	6 Leaking transformers on roof of 707 that flowed to ground via downspouts. PCB contamination.	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	<1 to 180 mg/kg (subsurface soil)
131	1986	Leaking Transformers - B707	700	E2084000	N750000	Transformers 701-1, 701-2, 701-3, 701-4, 701-5, 701-6 located East side of B707 roof. Concrete under several transformer drain valves found contaminated with PCBs. Visible evidence of leaking observed. Pad on roof and soil on ground contaminated and resulted in rainwater contamination collecting on rooftop and releasedthrough downspout to ground.	1	0	0	0	0	0	0	0	0	0	coolant oil	not specified	not specified	In 1988,Concrete wipe samples PCBs=135-7200 ppm and under downspout PCBs=1600ppm.
132	1986	Leaking Transformer - Bldg 708	700	E2084000	N750000	Leaking transformer with PCBs, west side of Bldg 708	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	detected (units questionable)
133	1986	Leaking Transformer - B708	700	E2084000	N750000	Transformer 708-1 located on west side of B708. Concrete pad contaminated with PCBs. Employees say electrical equipment west of B708 leaked PCB oil prior to 1987.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	In 1992, concrete wipe samples PCBs=1035-3750g and soil samples around pad PCBs=880ppm
134	1986	Transformer Leak - 779-1/779-2	700	E2084500	N750500	Leaking transformer with PCBs, northeast side of Bldg 779	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
135	1986	Compressor Waste Oil spill - Bldg 776	700	E2083670	N750670	2 separate incidents, occurring 2 days apart in June, 1986, involving 3 - 5 gallons of oil, north of 776	0	0	0	0	0	0	0	0	1	0	0	5-Mar	not specified	not specified
136	1957	771/771 Footing Drain Pond	700	E2084025	N751150	Footing drains exposed to process waste line leaks - drain to Bowman's Pond (N. side of 771). Nitrates and PCBs.	1	0	0	0	0	0	0	0	0	1	0	not specified	not specified	— 78.7 - 105.4 mg/L (nitrate)
137	1987	Leaking Transformer - Building 750	700	E2084500	N750000	Leaking transformer on northeast side of Building 750.	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
138	1987	Leaking Transformer - B750	700	E2084500	N750000	Transformer 750-1 located on northeast side of B750 crack in berm surrounding transformer. Transformer leaked dielectric fluid.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	1991 soil samples PCBs=160ppm. 1995 soil samples PCBs<6ppm
139	1986	Leaking Transformer - 776-5	700	E2084500	N750000	Transformer 776-5 leaking (west of Building 714)	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
140	1986	Leaking Transformer - B776-5	700	E2084500	N750000	Transformer 776-5 located on west side of B714 in protected area (PA) leaked coolant oil in 1986.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	Highest conc. on concrete pad PCBs=88ppb
141	1995	Water Released from the 207C Solar Evaporation Ponds	700	E2085230	N750529	Pinhole sized leak noticed in pressurized hose when snowmelt pumping from 207C.	0	0	0	0	0	0	0	1	1	1	"F-listed" VOCs	5	1.5 x 4	not specified
142	1996	Release during liquid transfer operations from B774	700	E2084189	N751126	Tanker truck from Oak Ridge, Tennessee transfer incident. Personnel observed liquid dripping from vacuum pumping apparatus onto pavement and soil.	1	1	1	0	0	0	0	1	1	0	waste oil, methylene chloride	< 55 gallons	not specified	PCBs<2ppm, TCE=250ppm, methylene chloride=33ppm, TCA=930ppm
143	1997	Identification of Diesel Fuel in Subsurface Soils	700	E2083882	N749720	While excavating a shallow trench on northeast corner of B708, strong diesel odor and oil staining encountered to a 2' depth.	0	0	0	0	0	0	0	0	0	0	deisel fuel, xylene, toluene, ethylbenzene	not certain	not specified	water and soil data for listed contaminents listed
144	1998	Leaking Transformer South of Bldg. 776	700	E2083775	N750350	Transformer discovered (1/19/98) to be leaking dielectric fluid to concrete pad and surrounding rock/ soil (unknown duration of leak - in service since April 1957)- 2 gallons, maybe more	1	0	0	0	0	0	0	0	0	0	0	2 (could be more due to unknown duration of leak)	Implied small area, but unspecified	21 to 23 ppm PCB
145	1998	Building 701 Water Line Soil Put-back	700	E2083751	N750703	Excavated soils found to contain low levels of CCL4. Soils were eventually returned to ground	0	0	0	0	1	0	0	1	0	0	0	release volume unknown- 5 yd3 of soil	small (5 yd³ of soil)	100 ppb CCL4
146	-	Radioactive Site - 700 Area Site #3 - Wash Area	700	E2084250	N751150	Wash water from rad-contaminated equipment, may have had organic compounds.	0	0	0	0	0	0	0	1	1	0	0	not specified	not specified	not specified
147	1983	Valve Vault 7	700	E2083700	N749855	Valve malfunctioned and process wastewater with solvents, oils and nitate overflowed from Valve Vault 7	0	0	0	0	0	0	0	1	1	1	0	not specified	not specified	not specified

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
148	1983	Valve Vault 7	700	E2083700	N749855	Southwest of B707, valve vault 7 controls 800 Area main process waste line.	0	0	0	0	0	0	0	1	1	0	nitric acid, hydrochloric acid, uranium, Be, F	not specified	not specified	not specified
149	1958	Valve Vault West of Building 707	700	E2083700	N749855	Leaking process waste line flowed into ditch N.E. of present location of 707 (707 not there at the time). Process waste contained solvents, oil, nitric acid.	0	0	0	0	0	0	0	1	1	0	0	4050	not specified	54 mg/L NO_3
150	1953	Tanks #66, 67 and 68	700	E2084145	N751035	Overflow of tanks with process waste water east of Building 374. Water high in nitrates. (See IHSS 125)	0	0	0	0	0	0	0	0	0	1	0	500	not specified	not specified
151	1952	Holding Tank (Tank #66)	700	E2084145	N751035	Process waste spill from tank (see IHSS 124.2)	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	not specified
152	1953	Out-of-Service Process Waste Tanks	700	E2083715	N751185	Out-of-service process waste tanks. Overflowed several times prior to 1958. High in nitrates.	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	not specified
153	1956	Radioactive Site - 700 Area - Site Number 4	700	E2083910	N750710	Tanks beneath B730, B771 and B776. (a.k.a. T-9 and T-10 Tanks)	0	0	0	0	1	0	0	1	0	0	laundry waste, VOCs	not specified	not specified	not specified
154	1955	Process Waste Line Leaks	700	E2083705	N749455	Process waste line leaks near 881, 441, and 444. Nitrate and solvents possibly in process waste.	0	0	0	0	0	0	0	1	0	1	0	not specified	not specified	>100 ppm
155	1972	Effluent Pipe	700	E2084220	N751052	Process waste line leaks and breaks near 774	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	10,000 mg/L nitrate
156	1957	Radioactive Site North of Building 771	700	E2083893	N751235	Several incidents of leaking drums with potential releases of solvents or nitrate	0	0	0	0	0	0	0	1	0	1	0	not specified	not specified	not specified
157	1971	Radioactive Site Between Buildings 771 and 774	700	E2083980	N751000	Leaks in concrete tunnel with process waste lines. Flange broken in late 1970s	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	not specified
158	1953	Radioactive Site West of Building 707	700	E2083600	N749831	Leaks of process waste from valve vault 7 (west of Bldg 707)	0	0	0	0	0	0	0	1	1	1	0	not specified	not specified	not specified
159	1969	Radioactive Site South of Building 776	700	E2083775	N750350	Oil and gravel placed over soil contaminated with Pu from fire	0	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
160	1986	Solvent Spill	700	E2084075	N749885	Approx. 4 gallon spill of TCA to ground near southeast dock of 707	0	0	1	0	0	0	0	1	0	0	0	4	implied small area, but unspecified	not specified
161	1986	Solvent Spill	700	E2084075	N749885	Forklift punctured 55-gal drum of TCA on southeast dock of B707. Leaked onto loading dock and adjacent pavement.	0	0	1	0	0	0	0	1	0	0	0	4	not specified	not specified
162	1986	750 Pad Pondcrete and Saltcrete storages	700	E2084500	N750100	Periodic spills of pondcrete and saltcrete, exposed to elements and impacted runoff.	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	not specified
163	1958	Oil Sludge Pit	800	E2084169	N747740	30-50 drums nonradioactive materials dumped in pit south of B881. Material consisting of oil sludge from tank cleanouts. No. 6 fuel oil known to be stored.	0	0	0	0	0	0	0	0	1	0	No. 6 fuel oil	not specified	25 x 50	not specified
164	1958	B881 East and West Out-of-Service Fuel Tanks	800	E2083948	N748158	Diesel fuel tanks	0	0	0	0	0	0	0	0	0	0	diesel fuel	not specified	not specified	not specified
165	1952	Outfall	800	E2083837	N748028	1950s and 1960s intermittent discharging of untreated sanitary waste occurred south of B881	0	1	0	1	0	0	0	1	0	1	untreated sewage and other waste	not specified	not specified	not specified
166	1985	Transformer 883-4	800	E2084000	N749000	PCB-contaminated transformer oil leak onto pad	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	>500 ppm PCBs
167	1985	Transformer 883-4	800	E2084000	N749000	Transformer 883-4 at southeast corner of B883 leaked on concrete pad.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	Historical records PCBs in oil =500ppm. In 1992, PCBs in oil=9ppm. Soil PCBs=up to 160ppm.
168	1987	Transformer 881-4	800	E2084000	N749000	Transformer 881-4 northside of B881 leaked on valves tap and pad.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	Oil contained PCBs=110ppm
169	1991	Leaking transformers, 800 Area	800	E2084000	N749000	PCB-contaminated transformers may have leaked oil, stains at valve	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
170	1991	Leaking Transformers, 800 Area	800	E2084000	N749000	Three transformers on the North side of B883 leaked prior to 1987 retrofitting. Oil stains visible. Area bermed, no drains.	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	In 1985, oils=17-84ppm. In 1992, oils=3-35ppm. In 1991, soils<7ppm
171	1997	Transformers 865-1 and 865-2	800	E2084000	N749000	PCB-contaminated transformer oil leaks	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	110 ppm PCBs
172	1988	Capacitor Leak, Bldg 883	800	E2084000	N749000	small oil leak (1 pint)	0	0	0	0	0	0	0	0	1	0	0	0.125	not specified	not specified
173	1992	B886 Sump	800	E2084400	N749100	Lubricating oil residue in sump pit determined to have originated in waste tanks.	0	0	0	0	0	0	0	0	1	0	lubricating oil	35	not specified	not specified
174	1964	B881 Conversion Activity Contamination Area	800	E2083705	N749455	Interviews say miscellaneous equipment stored in area such as lathe parts and rolling mill parts. Aerial photos show items in this area. In 1969 area covered by a parking lot.	0	0	0	0	0	0	0	0	1	0	Ca, Zn	not specified	50 x 150	not specified
175	1953	Building 881 Drum Storage Area, Room 165	800	E2083875	N748500	Drum storage area	0	0	0	0	0	0	0	0	0	0	chemical materials	not specified	not specified	not specified
176	1970	Building 885 Drum Storage Area, Room 165	800	E2084100	N749000	Drum storage area	0	0	0	0	0	0	0	1	0	0	0	not specified	96	not specified
177	1981	Building 883 Drum Storage Area, Room 104	800	E2083910	N748925	Drum storage area	0	0	0	0	0	0	0	1	0	0	0	not specified	160	not specified

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
178	1958	903 Pad	900	E2086000	N749000	Leaking drums with waste oil	0	1	0	1	1	0	0	1	1	0	0	2750	not specified	not specified
179	1958	903 Pad	900	E2086000	N749000	Leaking drums with waste oil	0	1	0	1	1	0	1	1	1	0	0	5000	not specified	not specified
180	1968	West Scrap Metal Storage Area	900	E2084840	N748145	Scrap metal storage in drums and on ground	0	0	0	0	1	0	0	1	1	1	0	not specified	not specified	not specified
181	1968	West Scrap Metal Storage and Solvent Spill Area	900	E2084840	N748145	Scrap metals possibly coated with solvents, residual oils, and/or hydraulic coolants were stored at this location between Sept 1968 and November 1971. GW extraction was initiated in 1993 to extract VOC-contaminated GW. Sampling in 1997 indicated no significant VOC contamination by VOCs	0	0	0	1	0	0	0	1	1	1	0	not specified	100,000	not specified
182	1968	West Scrap Metal Storage Area	900	E2084840	N748145	Scrap metal storage in drums and on ground	0	1	0	1	1	0	1	1	1	1	0	not specified	not specified	not specified
183	1968	West Scrap Metal Storage Area	900	E2084840	N748145	Scrap metal storage in drums and on ground	0	0	0	0	1	0	0	1	1	1	0	not specified	not specified	not specified
184	1968	West Scrap Metal Storage and Solvent Spill Area	900	E2084840	N748145	This area is one of two scrap metal storage areas. Pieces of scrap metal from barious buildings having residual oils and/or hydraulic coolants dripped onto soil. Scrap metal stored in drums or on ground.	0	0	0	0	0	0	0	1	1	1	oils, hydraulic coolants, solvents	not specified	not specified	not specified
185	1968	West Scrap Metal Storage Area	900	E2084840	N748145	Scrap metal storage in drums and on ground	0	1	0	1	1	0	0	1	1	1	0	not specified	not specified	not specified
186	1968	East Scrap Metal Storage Area	900	E2085455	N748400	Scrap metal storage in drums and on ground	0	0	0	0	1	0	0	1	1	1	0	not specified	not specified	not specified
187	1968	East Scrap Metal Storage Area	900	E2085455	N748400	Scrap metal storage in drums and on ground	0	0	0	0	1	0	0	1	1	1	0	not specified	not specified	not specified
188	1968	East Scrap Metal Storage and Solvent Spill Area	900	E2085455	N748400	This area is one of two scrap metal storage areas. Pieces of scrap metal from barious buildings having residual oils and/or hydraulic coolants dripped onto soil. Scrap metal stored in drums or on ground. North of SE Perimeter Road.	0	0	0	0	0	0	0	1	1	1	oils, hydraulic coolants, solvents	not specified	not specified	not specified
189	1957	Low-Level Radioactive Waste Leak	700	E2084200	N750750	Process waste line leak. Process waste high in nitrates	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	not specified
190	1989	Gasoline Spill	900	E2085250	N748760	2 gallon gasoline spill	0	0	0	0	0	0	0	0	0	0	gasoline	2	implied small area, but unspecified	not specified
191	1986	Transformers 991-1 and 991-2	900	E2085500	N748000	Oil with PCBs leaked from transformers to ground	1	0	0	0	0	0	0	0	1	0	0	not specified	implied small area, but unspecified	114 ppm (991-1) 60 ppm (991-2)
192	1986	Transformers 991-1 and 991-2	900	E2085500	N748000	Several leaks observed on flanges, valves, gauges, bushing compartments. Large amounts of oil were noted under the two transformers	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	Oil concen. 60-114ppm. Highest conc. on concrete pad PCBs=510ppb
193	1996	Release of F001 Listed Waste Water to Soil	900	E2086231	N749995	Wastewater leaking from level-indicating valve associated with SW-59 tank	0	1	0	1	1	0	0	1	0	0	chloroform	1 pint	not specified	not specified
194	1991	OU2, Field Treatability Unit	900	E2082000	N750000	Contaminated water designated as "F001" were released. Material soaked into soil.	0	1	1	1	1	0	1	1	1	0	chloroform, toluene, "F001 List"	10	not specified	not specified
195	1993	OU2, Field Treatability Unit	900	E2082000	N750000	Contaminated water designated as "F001" were released. Material soaked into soil.	0	1	1	1	1	0	1	1	0	0	dichloroethene, chloroform	10	not specified	TCE= 064mg/L, CCl4=.14mg/L, PCE=.054mg/L, DCE=.06mg/L, DCA=.002mg/L, TCA=.009mg/L, chloroform=.024mg/L
196	1993	OU2, Field Treatability Unit	900	E2082000	N750000	Potentially contaminated water from influent pipe system leading from Walnut Creek to OU2 treatment system released to environment.	0	1	0	1	1	0	1	1	0	0	"F001" list, methylene chloride, DCA, chloroform	10	not specified	not specified
197	1992	Hillside spill North of Solar Evaporation Pond 207B North	900	E2085000	N751000	Interceptor trench ditch water release due to a pipe freeze resulting in back pressure in the pipe when interceptor central sump began to pump water into the pond	0	1	0	0	1	0	0	1	0	0	toluene	490	not specified	CCl4=11ug/L, toluene=5ug/L, TCE=7ug/L
198	1952	Septic Tank East of B991	900	E2086231	N749995	200-300 yards east of B991 described brownish, odorous liquid flwoing from roughly 4-inch diameter metal pipe into wooden structure where carpenters were working. Carpenter believed source of liquid was office buildings to west. Wooden flume believed to have transported sewage effluent from waste disposal septic tank to ditch East of B991, likely B-2	0	0	0	0	0	0	0	0	0	1	0	one report estimated at 5-gallons/day	not specified	not specified
199	1994	Seep Area Near OU2 Influent Piping	900	E2086231	N749995	Glossy sheen observed on a pool determined to be from anaerobic degradation typical of "pond scum". Sample results indicate presence of VOCs.	0	1	1	1	1	1	1	1	1	0	benzene, VOCs	4	not specified	TCE=.3ug/L, PCE=.3ug/L, vinylchloride=84ug/L, DCE=2ug/L, DCA=24ug/L, benzene=.2ug/L

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
200	1994	Solar Evaporation Pond 207B Sludge Release	900	E2085230	N750529	"F-listed" waste sludge spilled along east berm of pond when a damaged latching mechanism of vacuum truck did not properly seal.	0	0	0	0	0	0	0	1	1	0	"F-listed"	1 quart	not specified	not specified
201	1994	Tanker Truck Release of Hazardous Waste on East Patrol Road, North of Spruce Ave.	900	E2085900	N750550	Tanker truck transporting decant from B750 storage pad to Tank 231 A and B when noticed liquid splashing out vent valve. Valve inadvertently left open during filling process. Decant contaminated asphalt and soil.	0	0	0	0	0	0	0	1	1	1	"F-listed", VOCs	10	100	not specified
202	1995	Soil Release from Wooden Crate in 964 Laydown Yard	900	E2085500	N750500	Material released from wooden half crate of unknown origin marked "oil and soil"	0	0	0	0	0	0	0	1	1	0	waste oils, VOCs	not specified	not specified	not specified
203	1956	Hazardous Disposal Site	900	E2086125	N748737	Trench disposal area	0	0	0	0	0	0	0	1	0	0	0	not specified	not specified	not specified
204	1956	Hazardous Disposal Site (IAG Name: Reactive Metal Destruction Site)	900	E2086125	N748737	Location was used for destruction and disposal of reactive metals and other chemicals including unspecified solvents from 1956-1970. Borehole results indicate only low concentrations of PCE. Proposed for NFA.	0	0	0	1	0	0	0	1	0	0	0	not specified	75,000	not specified
205	1956	Hazardous Disposal Site	900	E2086125	N748737	Trench disposal area	0	1	0	1	1	0	0	1	0	0	meth chloride	not specified	not specified	not specified
206	1952	Sludge Disposal	900	E2086458	N750358	Sludge overflows beds toward East Perimeter Road overlying claystone. Sludge enters B995 treatment processes. Material from drying beds became airborne during windstorms.	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	not specified
207	1966	Triangle Area	900	E2085700	N750650	Drum storage area	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	not specified
208	1952	South Dock Bldg 991	900	E2085350	N749875	Dock area with potential spills	0	0	0	1	1	0	0	1	0	0	acetone	not specified	not specified	not specified
209	1980	Contractor Storage Facility	900	E2084945	N750080	Drum storage area w/ oils and thinners	0	0	0	0	0	0	0	1	1	0	0	not specified	825	not specified
210	1960	S&W Contractor Storage Yard	900	E2085500	N750500	Contractor storage yard including drums with waste oils and organics, plus wind-blown nirate from solar ponds	0	0	0	0	0	0	0	0	1	1	0	not specified	not specified	not specified
211	1963	Gas Detoxification Area	900	E2088005	N748800	Selected gases detoxified using various neutralization processes including water, acid, caustic, carbon or air. Byproducts were disposed of as process wastes.	0	0	0	0	0	0	0	0	0	0	methylene chloride, acetone	not specified	not specified	not specified
212	1963	Gas Detoxification Area	900	E2088005	N748800	Possible VOC release(s) from Bldg 952, but not documented	0	0	0	0	0	0	0	0	0	0	meth chloride and acetone	not specified	not specified	not specified
213	1963	Gas Detoxification Area	900	E2088005	N748800	B952 constructed to store hazardous gases.	1	0	0	0	0	0	0	0	0	0	VOCs, SVOCs, methylene chloride	unknown	not specified	not specified
214	1986	Bldg 980 Cargo Container, Unit 16	900	E2085325	N749785	Cargo container and nearby outdoor area used for storing oils, thinners, solvents, fuels, paints, etc.	0	0	0	0	0	0	0	1	1	0	0	not specified	not specified	not specified
215	1987	904 Pad	900	E2085275	N749000	Outdoor storage areas, covered protection added later	0	0	0	0	0	0	0	0	0	1	trace VOCs	not specified	129,505	not specified
216	1952	Building 122 Medical Facility	100	E2081500	N749200	55-gallon drum of "liquid waste" rusted and leaked under building.	0	0	0	0	0	0	0	0	0	0	not specified	not specified	single 55 gallon drum	not specified
217	1953	Building 123 Health Physics	100	E2081700	N749200	Waste chemicals including ether and nitric acid "dumped out window"	0	0	0	0	0	0	0	0	0	0	ether	not specified	not specified	not specified
218	1953	B123 Under Building Contamination	100	E2081700	N749200	SVOCs in surface soils	0	0	0	0	0	0	0	0	0	0	residual SVOCs	not specified	not specified	slightly greater than MDLs and background in soil, methylene chloride in subsurface soil greater than Tier II, data suite available
219	1956	Picric Acid Burn Site	700	not specified	not specified	Picric acid from B771 was disposed of by burning in a small open pit east of patrol fence (June).	0	0	0	0	0	0	0	0	0	0	picric acid	0.5 pounds	"Small open pit", but not specifically described	not specified
220	1957	Building 771	700	E2083800	N751000	TCE used to clean and prepare concrete floors (October 1957)	0	1	0	0	0	0	0	1	0	0	0	not specified	not specified	not specified
221	1957	Building 771	700	E2083800	N751000	TCE used to clean and prepare concrete floors (October 1957)	0	1	0	0	0	0	0	1	0	1	0	not specified	not specified	not specified
222	1963	Nickel Carbonyl Container Burial	900	E2085500	N750500	Four 55-gallon drums, one GI can with 2 cylinders,a nd six loose cylinders of nickel carbonyl (NiCO)$_4$ were moved from a pit wet of 771 to a pit east of the Solar Ponds. Explosive charges were used to vent the containers (June 17 and 18)	0	0	0	0	0	0	0	0	0	0	Nickel Carbonyl	not specified	not specified	not specified
223	1964	Drum Spill - 84 Intersection	800	not specified	not specified	Oil spilled from 30-gallon drum (December 31)	0	0	0	0	0	0	0	0	1	0	oil	<30 gallons	not specified	not specified
224	1964	Building 776	700	E2083750	N750500	A tagged out valve was opened allowing carbon tetrachloride to overflow a lathe box and flow through a crack in the floor, contaminating the room below (October 1964)	0	0	0	0	1	0	0	1	0	0	0	not specified	not specified	not specified
225	1964	Carbon Tetrachloride Spill - Building 776	700	E2083750	N750500	5-gallon can of rad-contaminated carbon tet spilled to ground surface in 776 solvent storage area (July 21)	0	0	0	0	1	0	0	1	0	0	0	< 5 gallons	2	not specified
226	1969	B889 Under Building Contamination, including Tank 28	800	E2083850	N749100	Housed decontamination and waste reduction operations. Also included equipment decontaiminated by steam cleaning for reuse or sent off-Site. HEPA filters, combustible wastes, and non-reusable equipment compacted and shipped off-Site. Tank 28 connected to OPWL.	0	0	0	0	0	0	0	0	0	0	VOCs, SVOCs	not specified	not specified	soil data available, subsurface soil data available for Tank-28
227	1972	PIC-2 Limited Information	unknown	not specified	not specified	450 gallon oil storage tank overflowed (July) - unknown location and volume	0	0	0	0	0	0	0	0	1	0	oil	not specified	not specified	not specified
228	1974	Building 551 Chemical Leaks	500	E2082750	N749500	Leaking drum of Carbon Tetrachloride discovered May of 1974	0	0	0	0	1	0	0	1	0	0	0	not specified	implied small area, but unspecified	not specified
229	1975	PIC-2 Limited Information	unknown	not specified	not specified	Photos indicate removal of underground storage tank with holes - indicating release to subsurface - unknown contents, unknown time of release, unknown location, unknown volume	0	0	0	0	0	0	0	0	0	0	unknown	not specified	not specified	not specified
230	1980	Leaking Transformer - 771-1	700	E2084000	N751000	Transformer 771-1 was reported leaking at the drain valve in 1980, November 1985, June 1986, and September 1986.	1	0	0	0	0	0	0	0	0	0	dielectric fluid	unknown	implied small area, but unspecified	56 ppm PCB

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	Northing (Y)	DESCRIPTION	Contaminant Characteristics Type PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/ grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
231	1982	PIC-2 Limited Information	unknown	not specified	not specified	12 test drums with water sand and ethylene glycol dumped to ground and released to storm drain (unknown location and volume) June	0	0	0	0	0	0	0	0	0	0	ethylene glycol	not specified	not specified	not specified
232	1985	Diesel Oil Spill North of Building 559	500	E2083500	N750250	A portable air compressor was tipped over releasing 1 gallon of diesel fuel onto road surface. (April 6)	0	0	0	0	0	0	0	0	0	0	Diesel fuel	1	implied small area, but unspecified	not specified
233	1986	Diesel Oil Spill North of Building 776	700	E2083850	N750650	One gallon of diesel oil was spilled in alley north of 776 (March 19)	0	0	0	0	0	0	0	0	1	0	diesel	1	implied small area, but unspecified	not specified
234	1987	Fuel Oil Spill - Building 707	700	E2084000	N750000	28 gallons of deisel fuel released when fuel line damaged during construction activities (April 6)	0	0	0	0	0	0	0	0	0	0	No. 2 diesel fuel	28	not specified	not specified
235	1988	Hydraulic Oil Leak - Portal 2	300	E2084000	N751000	Hydraulic Oil releases - One in November and one in December	0	0	0	0	0	0	0	0	1	0	Hydraulic oil	Spill in November-unspecified volume; spill in December <5 gallons	implied small area, but unspecified	not specified
236	1988	Oil Spill - Building 886	800	E2084250	N749000	Portable air compressor leaked oil onto concrete (October)	0	0	0	0	0	0	0	0	1	0	Oil	not specified	implied small area, but unspecified	not specified
237	1989	Ethylene Glycol Spill - Building 443	400	E2082000	N749100	Release of 15 gallons of ethylene glycol from B443 #1 cooling system generator. Some seems to have leaked beyond concrete pad to environment (July 25)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	< 15 gallons	implied small area, but unspecified	not specified
238	1989	Asphalt Thinner Spill	900	E2085500	N749000	Five gallons of asphalt thinner spilled east of 904 pad (august 22)	0	0	0	0	0	0	0	1	0	0	alphalt thinner	5	not specified	not specified
239	1989	Air Compressor Rupture - Building 440	400	E2082250	N748250	Rupture of fuel line of portable air compressor. Spill to ground (July 6)	0	0	0	0	0	0	0	0	1	0	fuel oil	called "small spill", but not specified	implied small area, but unspecified	not specified
240	1989	Gasoline Spill South of Building 707	700	E2084000	N750000	One gallon of gasoline spilled off truck into soil (September 26)	0	0	0	0	0	0	0	0	0	0	gasoline	1	implied small area, but unspecified	not specified
241	1989	Coolant Spill - Building 729	700	E2084250	N750350	5 gallons of radiator coolant leaked onto ground outside building (November 13)	0	0	0	0	0	0	0	0	0	0	Coolant	5	implied small area, but unspecified	50% ethylene glycol, 50% water
242	1989	Hydraulic Fluid Leak - East Access Road	not specified	not specified	not specified	2 to 3 gallons of hydraulic fluid released from backhoe to gravel (August 24)	0	0	0	0	0	0	0	0	0	0	hydraulic fluid	3	implied small area, but unspecified	not specified
243	1990	Hydraulic Oil Spill - Building 707	700	E2084000	N750000	2.5 gallons of hydraulic oil released from broken forklift onto asphalt (December 7)	0	0	0	0	0	0	0	0	1	0	Hydraulic oil	2.5	implied small area, but unspecified	not specified
244	1990	Gasoline Spill East Side Building 662	600	E2083350	N748900	Unspecified volume of gasoline leaked from electricians truck (January 12)	0	0	0	0	0	0	0	0	0	0	gasoline	not specified	implied small area, but unspecified	not specified
245	1990	Antifreeze Leak - Building 334	300	E2082450	N749800	Roughly one gallon of antifreeze leaked from private vehicle onto parking lot near 334. (October 22)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	1	implied small area, but unspecified	not specified
246	1991	Antifreeze Leak - Building 130D Parking Lot	100	E2079600	N748150	Private vehicle released 2 quarts of antifreeze to asphalt (August 14)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	0.5	implied small area, but unspecified	water/ antifreeze mix (no specified %)
247	1991	Antifreeze Leak - Building 771 Parking Lot	700	E2083575	N750975	Private vehicle released 1.5 pints of antifreeze to asphalt (August 23)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	0.1875	implied small area, but unspecified	water/ antifreeze mix (no specified %)
248	1991	Antifreeze Leak - 205 Parking Lot	100	not specified	not specified	Private vehicle released 3 quarts of antifreeze to asphalt east of Building 111 (August 23)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	0.75	implied small area, but unspecified	water/ antifreeze mix (no specified %)
249	1991	Hydraulic oil Leak - Building 250	not specified	not specified	not specified	2 quarts of hydraulic oil spilled from a tractor to the soil south of Building 250 (the Windsite) - August 26	0	0	0	0	0	0	0	0	1	0	hydraulic oil	0.5	implied small area, but unspecified	not specified
250	1991	Air Compressor Oil Spill - Building 865	800	E2084000	N749025	1 quart of air compressor oil was released to the pavement west of 865. (August 29)	0	0	0	0	0	0	0	0	1	0	air compressor oil	0.25	implied small area, but unspecified	not specified
251	1991	Transmission Fluid Spill - Building 331	300	E2081950	N749700	3 gallons of transmission fluid spilled to asphalt and concrete east of 331 (Sept 4)	0	0	0	0	0	0	0	0	0	0	transmission fluid	3	implied small area, but unspecified	not specified
252	1991	Hydraulic Oil Spill - Building 115	100	E2081440	N749675	One gallon of hydraulic oil released from backhoe to soil west of 115. (September 12)	0	0	0	0	0	0	0	0	1	0	hydraulic oil	1	implied small area, but unspecified	not specified
253	1991	Hydraulic Oil Spill - Building 125	100	E2081475	N748875	One gallon of hydraulic oil released from trash truck to asphalt south of 125. (September 17)	0	0	0	0	0	0	0	0	1	0	hydraulic oil	1	implied small area, but unspecified	not specified
254	1991	Hydraulic Oil Spill Between 904 Pad and Building 331	300	E2085000	N748800	Ten gallons of hydraulic oil released from trash truck (most released southwest of 904 pad; less than 1 pint released in 331 parking lot) - Sept 24	0	0	0	0	0	0	0	0	1	0	hydraulic oil	10	not specified	not specified
255	1991	Gasoline Leak T130 Parking Lot	100	E2079550	N748150	half gallon of gasoline spilled onto pavement from private vehicle (September 30)	0	0	0	0	0	0	0	0	0	0	gasoline	0.5	implied small area, but unspecified	not specified
256	1991	Antifreeze Leak - Portal 1	700	not specified	not specified	One gallon of antifreeze mixture released from private vehicle to asphalt at Portal 1 (October 10)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	1	implied small area, but unspecified	50% ethylene glycol, 50% water
257	1991	Decontamination Water Spill	unknown	not specified	not specified	5 gallons of decon water containing TCE spilled from truck at several stops en route to building 231 (October 9)	0	1	0	0	0	0	0	1	0	0	0	5	not specified	18 ppb TCE
258	1991	Antifreeze Leak - Building 888 Parking lot	800	E2084150	N748950	1.5 gallons of antifreeze mixture released to asphalt parking lot of 888 (October 11)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	1.5	implied small area, but unspecified	50% ethylene glycol, 50% water
259	1991	Gasoline Leak Near 555 Power Station	500	not specified	not specified	0.5 gallons of gasoline leaked from private vehicle into ditch east of 555 power station (October 17)	0	0	0	0	0	0	0	0	0	0	gasoline	0.5	implied small area, but unspecified	not specified
260	1991	Air Compressor Leak - Building 440	400	E2082100	N748400	1.5 gallons of motor oil leaked from air compressor to asphalt north of 440 (october 21)	0	0	0	0	0	0	0	0	1	0	motor oil	1.5	implied small area, but unspecified	10W40 Motor Oil
261	1991	Motor Oil Leak - 441 Parking Lot	400	E2082000	N749200	1 quart of motor oil released to asphalt at 441 parking lot (October 29)	0	0	0	0	0	0	0	0	1	0	motor oil	0.25	implied small area, but unspecified	not specified
262	1991	Automatic Transmission Fluid Leak - Building 443	400	2082075	N749275	3 gallons of automatic tranmission fluid from and air compressor released onto soil northwest of 443. (October 29)	0	0	0	0	0	0	0	0	0	0	transmission fluid	3	implied small area, but unspecified	not specified
263	1991	Antifreeze spill - 441 Parking Lot	400	E2082000	N749200	7 quarts of antifreez mixture released from personal vehicle to asphalt of 441 parking lot (September 27)	0	0	0	0	0	0	0	0	0	0	ethylene glycol	1.75	implied small area, but unspecified	not specified
264	1991	Diesel Fuel Leak - Building 709	700	E2084000	N749750	1 quart of diesel fuel spilled from above ground storage tank near 709 (discovered July 17)	0	0	0	0	0	0	0	0	0	0	diesel fuel	0.25	implied small area, but unspecified	not specified
265	1955	Trench T-3	NE	E2086915	N749810	contaminated, burned and flattened oil drums	0	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
266	1955	Trench T-3	NE	E2086915	N749810	sewage treatment plant sludge, contaminated, burned and flattened oil drums, misc. waste	0	1	0	0	1	0	0	1	1	0	asphalt planking	not specified	not specified	not specified

REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/ grease	nitrates	other	Volume (gallons)	Area (ft^2)	Concentration
267	1965	Trench T-4	NE	E2087233	N749840	Sludge material disposal site, miscellaneous waste disposal including drums, asphalt and construction debris.	0	1	0	0	0	0	0	1	0	0	VOCs	not specified	11325	not specified
268	1955	Trenches T-4 thru T-11	NE	E2087475	N749690	asphalt planking materials and junk	0	0	0	0	0	0	0	0	1	1	0	not specified	130,000	not specified
269	1987	NE Buffer Zone Gas Line Break	NE	E2089000	N749500	NE Buffer Zone Gas Line Break	0	0	0	0	0	0	0	0	0	0	natural gas	5 MCF	not specified	not specified
270	1983	East Inner Gate PCB Spill	NE	E2086500	N749350	PCB-contaminated transformer oil leak onto asphalt	1	0	0	0	0	0	0	0	0	0	0	not specified	1	not specified
271	1991	Gasoline Spill	NE	E2093000	N749500	Gasoline Spill - B920 Guard Post	0	0	0	0	0	0	0	0	0	0	1	0.25	not specified	not specified
272	1992	Diesel Spill at Pond B-2 Spillway	NE	E2087500	N750800	18 gal. Diesel fuel leak	0	0	0	0	0	0	0	0	0	0	Diesel fuel	18	not specified	not specified
273	1992	Diesel Spill at Pond B-2 Spillway	NE	E2087500	N750800	18 gal. Diesel fuel leak	0	0	0	0	0	0	0	0	0	0	Diesel fuel	18	not specified	not specified
274	1991	OU2, Phase 2, Field Treatability Unit	NE	E2087177	N749971	Overfilling diesel fuel tank. Spilled onto ground while fueling operations taking place.	0	0	0	0	0	0	0	0	0	0	diesel fuel	20	not specified	not specified
275	1993	OU2 Test Well, Current Well No. 219-93	NE	E2087200	N750000	Groudwater spilled when casing inserted into new bedrock onto ground.	0	1	0	1	1	0	0	1	0	0	0	10	16	TCE=96mg/L, CCl4= 87mg/L, PCE=1.1mg/L, DCE=1.044mg/L, chloroform=1.1mg/L
276	1993	OU 2, Phase 2, Field Treatability Unit	NE	E2087000	N749900	Ruptured elbow in a secondary containment line as water was pumped to OU2 treatment facility.	0	0	1	1	1	0	1	1	0	0	"F001" listed contaminants	50	150	TCA=.011mg/L, DCE=.043mg/L, CCl4=.008, PCE=.02mg/L
277	1993	OU2 Test Well, Current Well No. 219-93	NE	E2087314	N750000	Groundwater spilled when casing inserted into new bedrock monitoring well forced water out of hole and onto ground.	0	1	0	1	1	0	1	1	0	0	chloroform	10	not specified	not specified
278	1993	Modular Tanks and B910 Treatment System	NE	E2085287	N751710	Liquid level in pumphouse secondary containment rose. Liquid siphoning out through the pump when discovered and operators closed valves manually.	0	1	0	1	1	0	0	1	0	0	chloroform, methylene chloride, toluene	0	N/A	organics below regulatory limit in mg/L (Land Disposal Restricted Constituent Conc treatment standard levels)
279	1993	Diesel Fuel Spill at Field Treatability Unit	NE	E2087290	N750008	Refueling emergency generator when automatic nozzle valve had not turned off as expected.	0	0	0	0	0	0	0	0	0	0	diesel fuel	4	200	not specified
280	1994	Diesel Fuel Spill at Field Treatability Unit	NE	E2087265	N749988	Refueling emergency generator during transfer of fuel from Tank B to Tank A to soil.	0	0	0	0	0	0	0	0	0	0	diesel fuel	20	not specified	not specified
281	1953	A-Series Drainage and Ponds	NE	E2086280	N751985	Recurring high nitrate concentrations in water leaving plant. Groundwater contamination and seepage.	0	0	0	0	0	0	0	0	0	1	0	not specified	not specified	120 mg/L nitrate to A-3
282	1978	Flume Pond - Walnut Creek Gaging Station (Walnut and Indiana Pond)	NE	E2093600	N753655	Pond sediment and stream sediment samples analyzed	0	0	0	0	0	0	0	1	0	0	toluene, acetone, 2-butanone, phenol	not specified	not specified, pull from design drawings	max. concentration data presented
283	1953	B-Series Ponds	NE	E2086975	N750430	Large amount of oil received at B995.	0	0	0	0	0	0	0	0	1	0	0	not specified	not specified	not specified
284	1964	Trenches South of Present Landfill	NE	E2084000	N752375	Trenches A,B, and C (Trench C consists of two smaller trenches)	0	1	1	0	0	0	0	1	0	0	2-butanol, toluene, sewage sludge	not specified	42100	not specified
285	1964	Trenches South of Present Landfill	NE	E2084000	N752375	Trenches A,B, and C (Trench C consists of two smaller trenches)	0	1	1	1	1	0	1	1	0	0	2-butanol, toluene, sewage sludge, styrene, chlorform, benzene, acetone	not specified	42100	max. concentration data presented
286	1975	Landfill Pond Center and South Area Spray Fields	NE	E2084425, E2084545	N753150, N752805	Low concentrations of phenol and nitrate detected in the spray water	0	0	0	0	0	0	0	0	0	1	phenol	not specified	23850	nitrate/nitrite = 5ppm
287	1989	East Spray Fields	NE	E2087550	N750100	East Spray Fields	0	0	0	0	0	0	0	0	0	0	acetone, 2-butanone, toluene	not specified	not specified	not specified
288	1979	East Spray Fields	NE	E2087550, E2088400	N751400, N749930	East Spray Fields	0	0	0	0	0	0	0	0	1	1	0	not specified	$20x10^{6}$ gal per year	not specified
289	1979	East Spray Fields - Center (216.2) and South Areas (216.3)	NE	E2088400	N749930	Spray fields North of Access Road operated only a few years and closed due to slumping and hillside erosion. South of Access Road operated for ~10 years. Spray to Central area: 1979-early 1980s and spray to South area: early 1980s-1990.	0	0	0	0	0	0	0	0	1	1	0	Total sprayed = 20 million gal/Year	not specified	not specified

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
290	1992	PU&D Yard Unit	NW	E2082050	N751550	Diesel fuel spilled onto ground during routine fueling operation for fork truck.	0	0	0	0	0	0	0	0	0	0	diesel fuel	1.5	not specified	not specified
291	1992	Present Landfill	NW	E2083007	N752622	Diesel fuel spilled onto asphalt surface while patching B850 parking lot. 50-lbs of soil and Oil-Dri absorbent tanken to landfill for disposal	0	0	0	0	0	0	0	0	0	0	diesel fuel	1	2604000	not specified
292	1992	Improper Disposal of Fuel-contaminated material at Landfill	NW	E2083573	N752668	Oil filter and oil-stained rags inadvertently disposed of in Present Landfill.	0	0	0	0	0	0	0	0	1	0	oil filters, oil stained debris	not specified	not specified	not specified
293	1994	Improper Disposal of Thorosilane-Contaminated Material at Landfill	NW	E2083537	N752613	Thorosilane contaminated material disposed of in sanitary landfill.	0	0	0	0	0	0	0	1	0	0	Thorosilane (consists of mineral spirits, naptha, diacetone alcohol)	5	not specified	not specified
294	1974	PU&D Storage Yard	NW	E2081800	N751575	PU&D Storage Yard	0	0	0	0	0	0	0	0	0	0	storage of contaminated drums	1000 empty drums	not specified	not specified
295	1974	PU&D Storage Yard	NW	E2081800	N751575	Storage of various containers, scrap materials, and equipment between 1974 and 1994. Detonation of reactive chemicals on three occasions in 1996 and 1997. Characterization in 1994 indicates VOCs present in soils in eastern third of yard. PCA and TCE found in one GW sample. Some stained soils observed.	0	0	1	1	0	0	0	1	0	0	methylene chloride; napthalene	unknown	eastern third of yard	in GW sample (PCE 15 ppb; TCA 8.3 ppb)
296	1974	PU&D Storage Yard	NW	E2081800	N751575	PU&D Storage Yard	0	0	0	1	0	0	0	1	0	0	storage of contaminated drums	1000 empty drums	not specified	not specified
297	1974	PU&D Drum and Dumpster Storage Facilities	NW	E2081830, E2082035	N751560, N751740	PU&D Drum Storage Facility (NW-174a) and PU&D Dumpster Storage Facilities (NW-174b)	0	0	0	0	0	0	0	1	1	0	waste oils, paints, solvents, coolants	not specified	not specified	not specified
298	1986	Inactive Hazardous Waste Storage Area	NW	E2082645	N752225	Inactive Hazardous Waste Storage Area	1	0	0	0	0	0	0	1	0	0	VOCs	not specified	not specified	trace PCB in material noted
299	1986	Inactive Hazardous Waste Storage Area	NW	E2082645	N752225	Inactive Hazardous Waste Storage Area	1	0	0	0	0	0	0	0	1	0	transformer oil	not specified	not specified	PCBs = 9.9 - 160 ppb
300	1955	C-Series Drainage and Ponds	SE	E2088260, E2088870	N747690, N747571	Ponds C-1 and C-2	0	0	0	0	0	0	0	0	1	1	untreated sanitary sewage	not specified	not specified	not specified
301	1955	Retention Ponds C-1 and C-2	SE	E2088260, E2088870	N747690, N747571	Constructed for temporary holding and to provide monitoring of Woman Creek waters (C-1). Constructed to re-route runoff from South Interceptor Ditch (SID) and southern protions of RFP main manufacturing area.	0	0	0	0	0	0	0	0	1	1	sanitary sewer overflow, automobile grease/fuel, PAHs	not specified	not specified	not specified
302	1955	Pond 7 - Steam Condensate Releases	SE	E2084000	N748000	Retention Pond South of B881, Sewage Lift Station (aka B887)	0	0	0	0	0	0	0	0	0	0	untreated sanitary sewage, B881 waste	not specified	not specified	not specified
303	1952	Original Landfill	SW	E2082000	N747800	Original Landfill	1	0	0	0	0	0	0	0	0	0	unknown nonradioactive hazardous chemical wastes	Landfill is $2x10^6$ ft^3	not specified	not specified
304	1955	Water Treatment Plant Backwash Pond (aka Pond 6)	SW	E2081500	N748000	South of B124	0	0	0	0	0	0	0	0	0	0	WTP backwash water	not specified	not specified	not specified
305	1952	Original Process Waste Lines, Tank 40	000	E2084000	N749000	two 400-gallon underground concrete tanks underlying a concrete vault approximately 7 feet deep installed in the mid 1950s and abandoned in 1981 or 1982	0	1	0	1	0	0	0	1	0	0	0	not specified	not specified	not specified
306	1968	Central Avenue Waste Spill	700, 900	E2084000	N749300	A drum being transported from the 903 pad to 774 dock leaked less than 10 gallons (1 drop/3 ft for 1.3 miles) of rad contaminated oil containing small amounts of CCL4 and perchloroethylene (June 11). 500 sq ft of surface soils were removed in the 774 dock area, and various washing and sealcoating was performed on the road surface.	0	0	0	1	1	0	0	1	1	0	0	less than 10 gallons	1.3 mile road length PLUS 500 sq ft at 774 dock	unknown
307	1992	Hillside Spill North of Solar Evaporation Pond 207B North	000	E2085100	N751000	approximately 490 gallons of interceptor trench water originating from the seperation of a pipe coupling in the 3" transfer line flowed onto surrounding soil	0	0	1	0	1	0	0	1	0	0	0	490	not specified	not specified
308	1953	Waste Leaks (IAG Name: Waste Spills)	100	E2081755	N749117	several small spill of nitrate-bearing wastes occurred around the outside of Building 123 from piping leading to an underground tank system behind Building 441 that collected wastes generated by both buildings	0	0	0	0	1	0	0	1	0	1	0	not specified	not specified	not specified
309	1989	Building 123 Bioassay Waste Spill	100	E2081730	N749040	Pump failed allowing waste to flow out of broken process waste line. Release was confined to excavation	0	0	0	0	0	0	0	0	0	0	Ammonia Thiocyanate, Ammonia Iodide; Ammonia Hydroxide	30	not specified but implied small	not specified
310	1989	Building 123 Bioasssay Waste Spill	100	E2081730	N749040	bioassay waste leaked into an excavation where a broken waste line was being repaired and mixed with rainwater in the excavation	0	0	0	0	0	0	0	0	0	1	0	30	not specified	not specified
311	1954	Building 111 Transformer PCB Leak	100	E2081500	N749500	Large electrical tranformer containing dielectric cooling oil containing PCBs found to be leaking (continous or intermittent unknown) into the secondary containment basin between 1984 and mid-1986	1	0	0	0	0	0	0	0	1	0	dielectric cooling oil	unknown	not specified by implied small	(Oil contained between 7 and 251 ppm PCB)

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	COORDINATES Northing (Y)	DESCRIPTION	Contaminant Characteristics Type: PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/grease	nitrates	other	Volume (gallons)	Area (ft^2)	Concentration
312	1989	Building 131 Transformer Leak	100	E2080500	N749000	A pole-mounted transformer leaked 0.25 gallons dielectric fluid (cooling oil) (19 ppb PCB) onto the asphalt surface below.	1	0	0	0	0	0	0	0	1	0	0	0.25	not specified, but implied small	Oil contained 19 ppb PCB
313	1980	Building 121 Security Incinerator	100	E2081400	N749250	incinerator was used to burn no carbon required (NCR)-type paper containing PCBs/ash was disposed of at the Present Landfill (PAC NW-114) in December 1980 (unknown whether this was standard practice throughout the incinerator's operating history)	1	0	0	0	0	0	0	0	0	0	0	"tons" of paper containing up to 10-20 percent PCBs were burned	not specified	not specified
314	1984	B334 Cargo Container Area	300	E2082525	N749745	Cargo area storing machine oils, solvents, machine coolants and low-level radioactive wastes. No berms surrounded area, but had a collection pan.	0	0	0	0	0	0	0	1	1	0	machine oils and coolants	not specified	not specified	not specified
315	1980	B371 Drum Storage, Unit 63	300	E2082235	N750390	Room 3420 in B371 stored drums of CCl_4, TCA, toluene	0	0	1	0	1	0	0	1	0	0	toluene	not specified	not specified	not specified
316	1992	Antifreeze spill North of B373	300	E2082633	N750872	Antifreeze spilled on pavement North of B373 by street sweeper.	0	0	0		0	0	0	0	0	0	antifreeze (50/50 ethylene glycol and water)	0.5	not specified	not specified
317	1994	Air Conditioner Compressor Release	400	E2082124	N748867	Stationary Operating Engineer noticed oil under air conditioning unit on roof of B444. Source of oil was a leak in a copper line to a pressure control device.	0	0	0	0	0	0	0	0	1	0	air conditioner oil (compressor oil), Freon 22	2	not specified	not specified
318	1993	Asphalt Surface near Building 559	500	E2083500	N750100	one gallon of wastewater being removed by tanker because it was found to exceed Segment 5 stream standards (from the P304 sump) spilled onto the pavement from a hose that was used to extract excess water from the tanker	0	0	0	0	0	0	0	0	0	0	VOCs	1	not specified	not specified
319	1997	Spills of Unknown Oil in PAC 600-1001 (SIR #318)	600	E2083000	N749000	Two oil stained areas found west of Bldg 663	0	0	0	0	0	0	0	0	1	0	oil	not specified	not specified	not specified
320	1965	Chemical Storage - South Site	600	E2082925	N749051	Oil released on road considered highly contaminated	0	0	0	0	0	0	0	0	1	0	0	2-3 L	900	not specified
321	1952	Nitric Acid Tanks (IAG Name, Multiple Acid Spills	600	E2082711	N748899	October 27, 1982-brown cloud of gas observed coming from the Acid Tank Farm; September 25, 1985, overfill occurred a filling operation; June 28, 1988, a level probe in a dumpster tank failed, causing a release of 1 gallon of nitric acid to the ground surface	0	0	0	0	0	0	0	0	0	0	nitric acid	unknown	unknown	unknown
322	1986	Transformer Leak - 776-4	700	E2083500	N750500	Reported to be leaking in Jan 1986 and again in Feb 1986. Oily film and staining visible on concrete pad and soil.	1	0	0	0	0	0	0	0	1	0	0	unknown	not specified by implied small	Soil samples showed 14,900 ppm in 1988. (Oil contained between 5 and 500 ppm PCB)
323	1972	771/774 Footing Drain Pond (AKA Bowmans Pond)	700	E2084067	N751245	physical failure of six process waste storage tanks contaminated soil around Building 774 from wastewater seeping into the soil	1	0	0	0	0	0	0	0	0	0	0	1000	not specified	not specified
324	1996	Releases During Liquid Transfer Operations from B774	700	E2084189	N751126	personnel observed liquid dripping from a pump apparatus of a tanker onto the pavement near B765 and confirmed approximately the same amount of liquid was releasd to soil at B774, where the pumping operation had taken place earlier	0	1	1	0	0	0	0	1	0	0	0	1	not specified	not specified
325	1983	Valve Vault 7	700	E2083700	N749855	Valve malfunctioned and process wastewater with solvents, oils and nitate overflowed from Valve Vault 7	0	0	0	0	0	0	0	1	1	1	0	not specified	not specified	not specified
326	1953	Radioactive Site West of Building 707	700	E2083600	N749831	Leaks of process waste from valve vault 7 (west of Bldg 707). Not distinct from IHSS 123.1 and 123.2. Proposed for NFA to clarify the redundancy	0	0	0	0	0	0	0	1	1	1	0	not specified	not specified	not specified
327	1953	B881 Drum Storage Area	800	E2083875	N748500	B881 storage area located in Room 165. Drums stored on floor with no berms.	0	0	0	0	0	0	0	0	0	0	VOCs	not specified	not specified	none
328	1970	Building 865 Drum Storage Area	800	E2084000	N749015	Drums were stored in Rm 145 containing VOCs, beryllium, rads, and chlorinated solvents. No indication of releases.	0	0	0	0	0	0	0	1	0	0	VOCs, chlorinated solvents	unknown	Rm was 12 x 8 ft	unknown
329	1970	B865 Drum Storage Area	800	E2084000	N749015	B865 storage area in Room 145. Drums stored on floor with no berms and no floor drains.	0	0	0	0	0	0	0	0	0	0	oils, chlorinated solvents	not specified	not specified	none
330	1981	Building 883 Drum Storage Area	800	E2083910	N748925	Drums were stored in Rm 104 containing waste oils: VOCs, beryllium, rads, and chlorinated solvents. No indication of releases.	0	0	0	0	0	0	0	1	1	0	0	unknown	Rm was 16 x 10 ft	unknown
331	1981	B881 Drum Storage Area, Unit 26	800	E2083975	N748250	55-gallon drums stored in Room 266B	0	0	0	0	0	0	0	1	0	0	materials containing solvents	not specified	200	none
332	1954	Trench T-1	900	E2086046	N749461	at least 125 drums containing lathe coolant buried in Trench 1	1	0	0	0	0	0	0	0	0	0	VOCs and lathe coolant	6875+	not specified	not specified
333	1993	Gasoline Spill Near Southeast Corner of B980	900	E2085075	N750150	0.7 gallons of gasoline spilled to bed of truck and ground surface during refueling near southeast corner of B980.	0	0	0	0	0	0	0	0	0	0	gasoline	0.5	not specified but implied small	gasoline
334	1993	Outside the Southeast Corner of B980	900	E2085075	N750150	Gasoline spilled onto ground (soil) during vehicle refueling	0	0	0	0	0	0	0	0	0	0	gasoline	1	not specified	not specified
335	1993	OU2 Field Treatability Unit	900	E2082000	N750000	potentially contaminated water from an influent pipe system leading from Walnut Creek to OU2 treatment system was released to the environment	0	1	0	1	1	1	1	1	0	0	chloroform, dichloroethane (DCA)	10	2 x 3	unknown
336	1952	Septic Tank East of Building 991	900	E2086339	N750199	sewage flowing into sewage disposal bed (or septic tank) believed to have been sewage	0	0	0	0	0	0	0	0	0	0	SVOCs	unknown	unknown	unknown
337	1994	OU2 Water Spill	900	E2088348	N750183	as a result of separation of piping transfer lines, approximately 200 gallons of surface water potentially containing hazardous waste constituents were released to the enviornment	0	1	1	0	0	0	1	1	0	0	chloroform, VOCs	200	unknown	unknown

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REFERENCE NUMBER	YEAR	UNIT NAME	AREA	COORDINATES Easting (X)	Northing (Y)	DESCRIPTION	Contaminant Characteristics Type PCB	TCE	TCA	PCE	CCl4	CHCl3	DCE	solvent	oil/ grease	nitrates	other	Volume (gallons)	Area (ft²)	Concentration
338	1994	Seep Area near OU2 Influent Piping	900	E2088175	N750185	during a CDPHE inspection of Walnut Creek, glossy liquid substance was noticed collection in a stagnant pool	0	1	0	0	0	1	1	1	0	0	N/A	3	2 x 2	unknown
339	1996	Release of F001 Listed Waste Water to Soil	900	E2086231	N749995	Waste leaked from level indicating valve for the SW-59 collection tank. Estimates of 1 pint of liquid leaked out VOCs before the valve was tightened. One 55-gallon drum of soil was removed, and the location was considered clean.	0	1	0	0	1	0	0	1	0	0	chloroform, trichloroethene, tetrachloroethene	0.125	not specified, but implied small	not specified
340	1996	Release of F001 Listed Waste Water to Soil	900	E2086231	N749995	Small contam. water leak (1 pint) to soil	0	1	0	1	1	0	0	1	0	0	chloroform	0.125	not specified	not specified
341	1965	Pallet Burn Site	900	E2085562	N749525	wooden pallets burned in area southwest of Oil Burn Pit No. 2	0	0	0	0	0	0	0	0	0	0	unknown	unknown	3800	unknown
342	1988	B980 Cargo Container, Unit 18	900	E2085085	N750140	Southeast of B980 used for solid and liquid wste drum storage for oil, solvents, and paint waste.	0	0	0	0	0	0	0	1	1	0	automotive oils, solvents, paints, paint thinner, grease, gasoline, diesel fuel, oily paper/rags	not specified	not specified	not specified
343	1992	Transformer 443-2	400	E2082000	N749500	Transformer 443-2 observed leaking small quantities of oil	1	0	0	0	0	0	0	0	1	0	0	not specified	not specified	12,000 ppm (oil) 230 ppm (soil)
344	1984	Trench T-3	NE	E2086915	N749810	(Original HRR- DOE 1992) dried material removed from the sludge drying beds (originating from the disposal of sanitary wastewater and sewage treatment plant sludge) along with miscellaneous waste including crushed drums, asphalt planking, and construction debris were disposed of in Trench T-3	0	0	0	1	1	0	0	1	0	0	0	not specified	not specified	PCE sampled ranging from 0.74 ppm to 6.3 ppm/CCl4 sampled at 1.6 ppm
345	1992	Diesel Spill at Pond B-2 Spillway	NE	E2087500	N750600	18 gallons of diesel fuel released from tank used for pump between pond B-2 and A-2. Thorough cleanup (Oct 27, 1992).	0	0	0	0	0	0	0	0	0	0	diesel fuel	18	pond B-2, and small area near pump	diesel fuel
346	1992	Retention Pond B-2, Walnut Creek Drainage	NE	E2087500	N750800	leak in a fuel tank of a portable pump used to transfer water from Pond B-2 to Pond A-2 spilled 18 gallons of diesel fuel directly onto the ground	0	0	0	0	0	0	0	0	0	0	Diesel fuel	18	not specified	not specified
347	1993	Diesel Fuel Spill at Field Treatability Unit	NE	E2087500	N750500	20 gallons of diesel fuel spilled as tank being filled (portable generator); Jan 14, 1993. Spill cleaned up with absorbents and excavation	0	0	0	0	0	0	0	0	0	0	diesel fuel	20	local area around portable generator	diesel fuel
348	1993	OU 2, Phase 2, Field Treatability Unit	NE	E2087500	N750000	overfilling a diesel fuel tank which supplied a portable generator for the OU 2 Field Treatment Facility	0	0	0	0	0	0	0	0	0	0	Diesel fuel	20	not specified	not specified
349	1992	771 Hillside Sludge	BZ	E2084600	N752000	80x80-ft zone of soil uncovered exhibiting odor indicative of sewage sludge. No record of sludge placement there. Only Chomium and Selenium found above background at time of sampling.	0	0	0	0	0	0	0	0	0	1	COD	unknown	80 x 80	unknown
350	1992	771 Hillside Sludge	NW	E2084600	N752000	possibility of waste disposal in a previously undisclosed location was identified in June 1992	0	0	0	0	0	0	0	0	0	1	0	N/A	1600	not specified
351	1993	OU 2 Treatment Facility	NE	E2087000	N749900	approximately 50 gallons of untreated seepage/spring water leaked from a ruptured elbow in a secondry containment line near the treatment facility	0	1	1	0	1	0	1	1	0	0	0	~ 50	150	not specified
352	1993	OU2 Test Well (current well # 21993)	BZ	E2087314	N750000	10 gallons of groundwater spilled during well installation	0	1	0	1	1	0	0	1	0	0	chloroform, 1,1 DCE	10	not specified	not specified
353	1993	Interceptor Trench Pump House	NE	E2085277	N751647	Release of water (RCRA F-listed haz waste) into Interceptor Trench System secondary containment	0	1	0	0	1	0	0	1	0	0	acetone, meth chloride	4700	not specified	not specified
354	1992	Diesel Spill at PU&D Yard	NW	E2081800	N751575	1.5 Gallon spill of diesel fuel in SE corner of PU&D Yard. Soil was excavated and containerized.	0	0	0	0	0	0	0	0	0	0	diesel fuel	1.5	not specified, but implied small	diesel fuel
355	1974	PU&D Storage Yard	NW	E2081800	N751575	contaminants detected in groundwater from borehole 18197, including trichlorotrifluoroethane	0	0	1	1	0	0	0	1	0	0	freon-based lathe coolant	not specified	not specified	not specified
356	1974	PU&D Storage Yard	NW	E2081800	N751575	1987-unknown powder spilled out of a drum while the drum, which had no bung and was believed to be empty, was being rolled to a truck for offsite recycling/1990-rainwater entered approximately 100 empty drums with the bungs unsecured/other releases may have occurred from leaking batteries, drums and scrap metal stored without prior decontamination	1	0	1	1	0	0	0	1	0	0	lathe coolant	not specified	not specified	not specified
357	1974	PU&D Drum Storage Facility / PU&D Dumpster Storage Facilities	NW	E2081830, E2082035	N751580, N751740	rainwater entered 100 empty drums and became contaminated with residual hazardous materials previously contained in the drums	1	1	0	1	0	0	0	1	1	0	freon-based lathe coolant	not specified	not specified	not specified
358	1992	Present Landfill	NW	E2083000	N752500	one gallon of fuel was spilled onto the asphalt surface while patching the B 850 parking lot, cleaned up with 50 pounds of soil and oil-dri absorbent and inadvertently taken to the landfill for disposal	0	0	0	0	0	0	0	0	0	0	Diesel fuel	1	2604000	not specified
359	1988	Inactive Hazardous Waste Storage Area	NW	E2082645	N752225	Area southwest of Present Landfill operated as soil and liquid waste storage area. Liquid waste drums were stored in cargo containers. Spills of less than reportable quantities occurred. Sampling indicates possible monor surficial contamination by metals, PCBs, rads, and possible VOCs. All low level.	1	0	0	0	0	0	0	1	1	0	unknown	unknown	unknown	sampling results all well below Tier II
360	1952	Ash Pits (Operable unit 5) (Six trenches total in IHSS 133)	SW	E2080257	N747555	Trenches were used for disposal of ash from the incinerator operated from 1952 to 1968. Trenches were 10 ft deep. Rad contamination found. Some VOCs in one well are considered to be anomolous (lab error at low levels). Downgradient VOCs considered to be from some other source- per HRR2001	0	1	0	1	0	0	0	1	0	0	methylene chloride; Benzene; Toluene; Tetrachloroethene; trichloroethene	not specified	2400	in Well 5686: methylene chloride 23 ug/L; Benzene 57 ug/L; Toluene 57 ug/L; Tetrachloroethene5 ug/L; trichloroethene 56 ug/L
361	1952	Incinerator Facility	SW	E2079445	N747740	Incinerator used to burn general site wastes (1952-1968)	0	0	0	1	0	0	1	1	0	0	benzene, toluene	not specified	not specified	not specified
362	1952	Incinerator	SW	E2079445	N747740	Near B219, south of West Access Road near Plant's original west boundary. 32-foot high incinerator used to burn off wastes. Present landfill constructed as substitute for incinerator and waste disposal.	0	0	0	0	0	0	0	0	0	0	0	not specified	not specified	not specified
363	1992	Transformer 443-2, Building 443	400	E2082000	N749500	transformer was observed leaking small quantities of oil - site was not originally sampled as part of of sitewide screening effort to categorize the 35 suspected PCB sites in August 1991	1	0	0	0	0	0	0	0	1	0	0	specified as leaking "small quantities"	not specified	soil surrounding transformer sampled at 230 ppm
364	1955	Fuel Oil Tank 221 Spills	600	E2082760	N749130	No. 6 fuel oil spilled during filling	0	0	0	0	0	0	0	0	1	0	0	700+400+50 = 1150	not specified	not specified
365	1987	Transformers 865-1 and 865-2	800	E2084000	N749000	Transformers 865-1 and 865-2 are on Northwest side of B865	1	0	0	0	0	0	0	0	0	0	0	not specified	not specified	1991 soils < 1.3ppm
366	1958	903 Pad	900	E2086000	N749000	drums containing lathe coolant and CCl4s stored from 1958 to 1987/leaking drums noted in 1964 during routine handling operations	0	1	0	0	1	0	0	1	1	0	N/A	5000	100,000	2000 to 300,000 dpm per 100cm²

Priority Factor

1	Spill of organic contaminant (including oil) > 100 gal (
2	Spill of organic contaminant (including oil) < 100 gal (
3	All other spills not rated a priority 2

REFERENCE NUMBER	IHSS INTEGER (for database search)	IHSS IDENTIFIER	PAC REFERENCE NUMBER	PIC REFERENCE NUMBER	OU REFERENCE NUMBER	DURATION (Years)	REMEDIATION ACTION: At Time of Incident	REMEDIATION ACTION: Time After Incident	REFERENCE DOCUMENT	COMMENTS	PRIORITY FACTOR
1	101	101	000-101	N/A	4	1953 through present	Over the years, various actions have been taken including resealing of pond linings, pumping of water from drain tiles and trenches back to ponds or to treatment.	Over the years, various actions have been taken including resealing of pond linings, pumping of water from drain tiles and trenches back to ponds or to treatment.	HRR 1998	The solar ponds represent a significant source of nitrate contamination to soil and groundwater in the immediate viscinity of the ponds and downgradient. Systems are currently in place to address the plume created by years of release. There will be some challenges simulating release times, volumes, and concentrations due to lack of records.	1
2	121	121	000-121	N/A	N/A	31	not specified	Some soil and pavement removed in some instances. In 1971, wells drilled around many OPWL tanks near buildings to monitor groundwater.	HRR Update 1996	-	1
3	192	192	000-192	N/A	16	1 day	diverted to B-1, flushed with 5000 gallons water		HRR 1992	B708 to B750 to 10th Street, Proposed IHSS 192 be enlarged to include B708	3
4	N/A	N/A	000-501	N/A	N/A	9.75	not specified	not specified	HRR 1992	Jan.1974-Sept.1983, lubrication oil rolling mill lube system	1
5	N/A	N/A	000-503	0	N/A	1 day	Pumps shut down which alerted B910 operators to spill. Operators manually closed valves.	Overflow pumped into portable tank and trucked to B374 for treatment. Wipes used to cleanup placed into drums.	HRR Update Quarter 5 (1993)	000-503 appears the same as 900-1308. Estimated amount released listed.	1
6	128	128	300-128	N/A	13	not specified	not specified	not specified	HRR 1992	smoke plume moved in general direction of B123, overlaps with solvent PAC 300-171 near B335	1
7	151	151	300-151	N/A	8	7	Reported that clean-up would begin when the ground dried, Some diesel applied to roads at RFP	No further documentation	HRR 1992	400 yd^3 of soil affected	1
8	129	129	400-129	N/A	10	Tanks 1-3 = 40 and Tank 4 = 19	No documentation was found	No documentation was found	HRR 1992	Sewage treatment plant unable to recover 600-gal of oil, but no documentation to support spill. Small spills were noted from 1952-1967 during B551 fuel transfers. Underground transfer lines installed in 1967 and these transfers ceased. Compressor oil found in post holes (4ft down), No. 6 fuel oil discovered in another post hole, additional released occurred and trace amounts of TCA discovered. Notes that not all spills reached a water course.	1
9	129	129	400-129	N/A	IA	45	not specified	Recovered 600 gallons in sewage treatment. Tank #4 cleaned and foamed.	HRR Update 1997	Stated the spill did not reach a drainage or watercourse for the 500 gallon spill. No documentation found detailing cause of the most recent, 1700 gallon, spill.	1
10	182	182	400-182	N/A	N/A	unknown	not specified	as of 1983, oil not cleaned up	HRR 1992	Prior to 1957 - Unknown.	1
11	117	117.2	500-117.2	N/A	13	17	recommendation made for repacking leaking drums	storage area covered with asphalt in 1970s	HRR 1992	Dates of Occurance state prior to approximately 1971 through Prior to September 1988. In 1986 the incident was controlled with no environmental damage per interviews or documentation.	1
12	197	197	500-197	N/A	N/A	2	Some material recovered	Inaccurate location of remediated location	HRR 1992	-	1
13	N/A	N/A	600-1000	N/A	N/A	4	-	No documentation found that detailing actual cleanup activities	HRR 1992	Documentation of inspection indicates 10 of 28 transformers were awaiting disposal rather than reuse b/c of their age or condition	1
14	N/A	N/A	600-1000	N/A	N/A	unknown	not specified	1983 a transformer shipped off-Site for disposal. 1986 28 transformers awaiting disposal.	HRR Update 1996	Dates of occurance "Prior to 1982, and through August 1986". Past activities occuring in the electrical yard from storage and repair practices are suspected to contribute to soil contamination near B662.	1
15	N/A	N/A	600-1001	N/A	N/A	17	not specified	Some decontamination activities	HRR 1992	Several documented releases and photos show cracks in concrete and drums	1
16	N/A	N/A	600-1001	N/A	N/A	17	not specified	Drums moved from slab to Mound Site for burial. Drums corroded and leaked all over pad. With exception to 1997 occurrence, soil containerized near B663 and transported to RCRA facility.	HRR Update 1997	1954-1971 and June 1997. 1959 photos show cracks in concrete where drums stored and circular stains from drums. Cracks in B663 floor show similar cracks in concrete and circular stains from drums. UBC sampling under B663 by M. Bemski (Oct. 2002) per John Boylan 10/2002 revealed rads and VOCs.	1
17	117, 152	117.3, 152	600-117.3, 600-152	N/A	IA	unknown	not specified	Removal of soil under glovebox and asphalt contaminated by leaking wastebox removed. Does not address Tank 221 cleanup.	HRR Update 1997	Prior to 1965 - 1969. OU13 sampling activities show future remedial action is not warranted for storage area, 117.3. Tabular data (soil-gas concentrations, RBC values) available for contaminants.	1
18	118	118.1	700-118.1	N/A	8	11	Efforts to stop leaking pipes early 1976. Removal of tank in 1981	not specified	HRR 1992	Large quantities of carbon tetrachloride released to environment. Overflows during filling operations, 100 - 200 gal. Spill in 70s, tank failure in June 1981. Tank base: 5978 ft (9.1 ft below grade), other details in HRR.	1
19	118	118.1	700-118.1	N/A	8	11	Efforts to stop leaking pipes early 1976. Removal of tank in 1981	not specified	HRR 1998	Large quantities of carbon tetrachloride released to environment. Spills prior to 1970, spills in 976, tank failure in June 1981. Tank base: 5978 ft (9.1 ft below grade). Little documentation of cleanup efforts. Zone of DNAPL exists in heterogeneous fill material around process waste tanks adjacent to CCL4 tank. Speculation that DNAPL is confined in bedrock depression.	1

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REFERENCE NUMBER	IHSS INTEGER (for database search)	IHSS IDENTIFIER	PAC REFERENCE NUMBER	PIC REFERENCE NUMBER	OU REFERENCE NUMBER	DURATION (Years)	REMEDIATION ACTION: At Time of Incident	REMEDIATION ACTION: Time After Incident	REFERENCE DOCUMENT	COMMENTS	PRIORITY FACTOR [illegible]
20	118	118.2	700-118.2	N/A	8	short-term event	Tank and area of soil was cleaned up	not specified	HRR 1992	5,000 gal carbon tetrachloride tank rupture. Not specified amt released. Tank between N. side of 707 and alley S. of 778.	1
21	102	102	800-102	N/A	1	1	not specified	not specified	HRR 1992	30 - 50 drums of oil sludge dumped in pit	1
22	103	103	800-103	N/A	1	unknown	not specified	not specified	HRR Update 1997	No documentation found detailing fate of constituents, or the site existence.	1
23	104	104	800-104	N/A	1	unknown	not specified	not specified	HRR Update 1997	No documentation found detailing fate of constituents, or the site existence.	1
24	107	107	800-107	N/A	1	1	Oil soaked up with straw.	Concrete skimming pond and interceptor trench built (1979)	HRR 1992	-	1
25	107	107	800-107	N/A	1	1	not specified	Tanks filled with concrete and asbestos. Phase II RI/RFI Report for OU1 indicated pond removed during construction of the french drain. RFP photographs document soil removal from site.	HRR Update 1997	Originally thought to be from two tanks, but footing drain passes under tanks. After 20 years of usage, the underground reservoir of waste oil developed to an extent it started seeping out of the hillside. Another theory is that oil originated from oil sludge pit 800-102. VOCs in groundwater. Well to the West Inidcated VOCs and rads.	1
26	N/A	N/A	800-1208	N/A	none	unknown	not specified	transformer retro-filled in 1987	HRR 1992	May have leaked prior to 1986, transformer holds 435 gallons. Very small contamination according to Demos (11/5/2002).	3
27	108	108	900-108	N/A	2	8	none	Remediated in 1998	HRR 1992	waste in drums included lathe coolant; trench was 10 feet deep (some info here from intranet)	1
28	108	108	900-108	N/A	2	8	none	Remediated in 1998 by removal	HRR 1998	waste in drums included lathe coolant; trench was 10 feet deep (some info here from intranet). 1998 remediation considered successful- drums removed.	1
29	108	108	900-108	N/A	2	8	none	Remediated in 1998, Excavation occurred from June 10 to August 20, 1998.	HRR 2000	waste in drums included lathe coolant; trench was 10 feet deep (some info here from intranet). T-1 was remediated in 1998.	1
30	109	109	900-109	N/A	2	24	not specified	not specified	HRR 1992	primarily sewage sludge, but also received 2400 gal. Of lathe coolant in 1964. Trench was 10 feet deep.	1
31	109	109	900-109	N/A	2	2	not specified	not specified	HRR Update 1996	Elevated VOC levels detected in groundwater down-gradient.	1
32	109	109	900-109	N/A	BZ	3	not specified	Trench backfilled in 1971. ~180 yd^3 excavated in 1995 and treated by low temp. thermal desorption. Treatment completed in 1996.	HRR Update 1997	-	1
33	109	109	900-109	N/A	BZ	2	-	Trench backfilled, ~180yd^3 soil and debris excavated and treated by low temp. desorption.	HRR Update 2002	NFA'd, but PAC amended to reflect contaminants in down-gradient groundwater monitoring well(s). Specifically Well 07391.	1
34	112	112	900-112	N/A	2	10	Soil covered with fill, base course and asphalt	Major remediation planned for Oct. 2002	HRR 1998	4 shallow wells drilled in Nov. 1989; additional wells drilled in 1987. High GW concentrations of PCE and CCL4 (10% of solubility) indicative of DNAPL source.	1
35	113	113	900-113	N/A	2	4	none	Drums removed in 1970. Contaminated soil removed March - Agust 1997	HRR 1992	Predominant contaminant was PCE. Volume of release (7700 gal.) based on 10% of 1405 drums leaking. Soil excavated down 17 ft. in 1997, including 5 ft. into bedrock (see closeout report for source removal at Mound, plus monitoring reports for Mound treatment system (on EDDIE)).	1
36	113	113	900-113	N/A	2	4	not specified	Drum removal completed in 1970. Treated soil and placed back in area in 1997.	HRR Update 1997	Odors and solvents detected by construction workers when they encountered groundwater during construction of the PSZ.	1
37	N/A	N/A	900-1312	N/A	2	1 day	Decision made not to remove soil impacted by release.	None of the material that wetted soil or flowed into the creek was recovered.	HRR Update Quarter 7 (1994)	Based on historical data the OU2 area contains all the contaminants marked "1" on "F001 List". Most detected above MCL, and some < MCLs. Lab data exists.	1
38	153	153	900-153	N/A	2	7	not specified	Approx. 240 boxes of soil removed in 1978	HRR 1992	Total number of drums burned in the pit estimated to be approximately 1354. Burned approx. 80 drums of oil in a typical month.	1
39	155	155	900-155	N/A	BZ	9	unknown	drum removal, grading and construction of asphalt pad completed by 1969, areas of 903 Lip Area surround the 903 Pad were graded with fill dirt over a wide area by 1971	HRR Update 1999	total of 37 shallow boreholes to characterize radiological contaminaton and 2 deep boreholes to characterize VOC contamination have been completed in the 903 Lip Area	1
40	N/A	N/A	N/A	N/A	N/A	8	in May 1959 wil burn residue and some flattened drums remaining in the oil burn pit were covered with fill material and signs posted to warn of contamination	burning of oil was halted in June 1965, approximately 240 boxes of soil were excavated in 1978 and shipped offsite for disposal	HRR Update 1999	unknown whether the removal of approximately 240 waste crates in 1978 sufficiently removed the source of contamiantion for the Oil Burn Pit No. 2	1
41	N/A	N/A	n/a	N/A	BZ	4	-	All drums were removed by May 1970. Source removal efforts involved removal, treatment, and replacement between March and September 1997. In Situ treatment system installed in 1998 to treat organics.	HRR 1998	Listed and described in "Other Significant Events". No associated PAC or IHSS in this discussion.	1
42	N/A	N/A	N/A	42	N/A	1	Fire dept constructed dike to prevent further spread. Soil applied to absorb contaminants. No record of removal of soil or further cleanup	-	HRR 1992	-	1

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43	110	110	NE-110	N/A	BZ	1	not specified	In 1996, 1706 yd^3 of VOC contaminated material removed from T-3 and treated. ~200 yd^3 of debris and crushed drums.	HRR Update 1997	2400 gallons of water and lathe coolant disposed of in the East Trenches.	1
44	111	111.1	NE-111.1	N/A	BZ	2	not specified	In 1996, 2094 yd^3 of VOC contaminated material removed from T-4 and treated. ~150 yd^3 of debris and crushed drums.	HRR Update 1997	2400 gallons of water and lathe coolant disposed of in the East Trenches.	1
45	N/A	N/A	NE-1412, NE-1413	N/A	2	14	-	Actively characterized within the scope and schedule of OU2	HRR Update Quarter 10 (1995)	Dates of east trenches are unknown. Newly identified trenches warrant further investigation.	1
46	142	142.5, 142.6, 142.7, 142.8, 142.9	NE-142.5, NE-142.6, NE-142.7, NE-142.8, NE-142.9	N/A	6	not specific	Some pumped to A-Series Ponds, but no specific quantities identified.	1980s some sediments removed, actions taken at B-5 to reduce potential for off-Site sediment movement and deposited in NE-156.2	HRR Update 1997	Plant opening - Early 1970s (~20 years) duration.	1
47	not specified	not specified	not specified	not specified	not specified	35	not specified	not specified	HRR Buildings 1994		1
48	not specified	not specified	not specified	not specified	not specified	37	not specified	not specified	HRR Buildings 1994		1
49	not specified	not specified	not specified	not specified	not specified	38	not specified	not specified	HRR Buildings 1994		1
50	not specified	not specified	not specified	not specified	not specified	39	not specified	not specified	HRR Buildings 1994		1
51	not specified	not specified	not specified	not specified	not specified	37	not specified	not specified	HRR Buildings 1994		1
52	not specified	not specified	not specified	not specified	not specified	32	not specified	not specified	HRR Buildings 1994		1
53	not specified	not specified	not specified	not specified	not specified	20	not specified	not specified	HRR Buildings 1994		1
54	not specified	not specified	not specified	not specified	not specified	22	not specified	not specified	HRR Buildings 1994		1
55	not specified	not specified	not specified	not specified	not specified	10	not specified	not specified	HRR Buildings 1994		1
56	not specified	not specified	not specified	not specified	not specified	not specified	not specified	not specified	HRR Update Quarter 3 (1993)		1
57	not specified	not specified	not specified	not specified	not specified	43	not specified	not specified	HRR Buildings 1994		1
58	114	114	NW-114	N/A	7	24	not specified	not specified	HRR 1992	1968-Present, "incidental activities have occurred at the landfill or landfill area which are poorly documented but which should be researched further to determine their significance."	1
59	114	114	NW-114	N/A	7	24	not specified	not specified	HRR Update Quarter 2 (1992)	Wide range of waste disposed of in Present Landfill	1
60	174	174	NW-174A	N/A	BZ	unknown	none; sampling of soil and GW	-	HRR 1998	limited information on VOCs released, volume released, time of release (Note: this PAC is presented with PAC NW-194B in HRR). These PACs overlap with IHSS 170.	1
61	174	174	NW-174B	N/A	BZ	unknown	none; sampling of soil and GW	-	HRR 1998	limited information on VOCs released, volume released, time of release (Note: this PAC is presented with PAC NW-194A in HRR). These PACs overlap with IHSS 170.	1
62	121	121	000-121	N/A	9	31	-	some removed/replaced, some abandoned	HRR 1992	1952-1983	1

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63	101	101	000-101	N/A	4	38	-	varies	HRR 1992	Detailed descriptions of operation, all ponds cleaned by 1991	2
64	168	168	000-168	N/A	11	3.5	not specified	not specified	HRR 1992	4 years vs. 3.5 years, Nitrate = 55.8mg/L at an application rate of 89,445 gal/acre.	2
65	168	168	000-168	N/A	11	3.5	not specified	not specified	HRR Update 1996	High nitrate concentrations in water sprayed in field and trace levies of VOCs and SVOCs. Most of nitrate/nitrite taken up as "fertilizer" by indigenous plants.	2
66	172	172	000-172	N/A	8	1 day	barricaded, some remained after clean-up, roadway sealcoated	none	HRR 1992	spilled on road/asphalt, Distance traveled = 1.3 miles	2
67	N/A	N/A	000-500	N/A	N/A	40	not specified	not specified	HRR 1992	1952-Present, Incidental/Accidental discharges listed	2
68	N/A	504	000-504	N/A	N/A	15	Spilled material at 100-611 containerized and transferred to B123 waste system. Valve Vaults 11,12, 13 repaired and contaminated soil removed. 700-147.1 soils excavated and removed.	N/A	HRR Update 1999	-	2
69	N/A	N/A	000-505	N/A	N/A	47	unknown	September 1970 two 55-gallon drums	HRR Update 1999	-	2
70	148	148	100-148	N/A	13	22	not specified	not specified	HRR 1992	1953-1975, UBC for B123, pipe probably constructed of "Duriron"	2
71	N/A	N/A	100-605	N/A	N/A	not specified	not specified	not specified	HRR 1992	Spilled on soil or pavement, "location...should be considered very approximate"	2
72	N/A	N/A	100-606	N/A	N/A	not specified	drum "righted" and valve replaced	-	HRR 1992	Material spilled on asphalt, determined not a reportable quantity for the EPA	2
73	N/A	N/A	100-607	N/A	N/A	32	-	Transformer repaired. In 1984, cooling oil samples <50ppmPCBs so no corrective actions taken.	HRR 2000	-	2
74	N/A	N/A	100-607	N/A	N/A	2	-	2	HRR 1992	Leaked onto underlying gravel	2
75	N/A	N/A	100-608	N/A	N/A	not specified	no spill clean-up initiated b/c <10 lbs and <50ppm of PCBs	-	HRR 1992	No documentation on repair or replacement was found	2
76	N/A	N/A	100-609	N/A	N/A	5	not specified	not specified	HRR 1992	Detailed dates of operation not documented, incineration of classified documents	2
77	134	134N, 134S	300-134	N/A	13	7			HRR 1992	1963-1970, During B335 excavation 5-6 yd^3 graphite uncovered	2
78	151	151	300-151	N/A	IA	7	not specified	Cleanup of saturated soil after ground dried in 1981.	HRR Update 1997	One detection of trichlorofluoromethane suggesting past spills cleaned up. One reference states one of spills did not reach a water course and that no environmental impacts were expected.	2
79	171	171	300-171	N/A	13	23	none	none	HRR 1992	diesel, gasoline and solvents, unaware of any type of soil removal prior to B335 construction. 1969-1992	2
80	181	181	300-181	N/A	10	2	No documented spill	No documented spill	HRR 1992	The storage container monitored weekly. No other documentation was found which detailed the response to this operation. No documentation of spills or leaks were found in relationship to this unit. No visual evidence of a release to environment.	2
81	212	212	300-212	N/A	15	not specified	not specified	not specified	HRR 1992	1980-Present	2
82	N/A	N/A	300-703	N/A	N/A	1 day	Water and dry chemical	-	HRR 1992	October 7, 1970	2
83	N/A	N/A	300-708	N/A	N/A	unknown	not specified	2 yd^3 excavated and sent off-Site for disposal	HRR Update 1996	Dates of occurance "Prior to 1991"	2
84	N/A	N/A	300-708	N/A	N/A	unknown	No leaks documented	No leaks documented	HRR 1992	Transformers all located within a rock-filled bottom.	2
85	N/A	N/A	300-709	N/A	N/A	11	not specified	not specified	HRR Update 1996	Dates of occurance 1975-1986	2
86	N/A	N/A	300-710	N/A	N/A	1 day	5 ft3 packaged and trasported to B331 accumulation area	-	HRR 1992		2
87	N/A	N/A	300-714	N/A	N/A	1 day	evaporator system shut down, liquid and contaminated spill removed	Follow up sampling	HRR Update Quarter 10 (1995)	-	2
88	116	116.2	400-116.2	N/A	12	39	not specified	not specified	HRR 1992	Environmental Control looking into removal of soils, but not known if accomplished. Air sampling performed in 1977 determined soil removal not necessary.	2
89	122	122	400-122	N/A	9	29.5	not specified	not specified	HRR 1992	Information developed indicates location may be inaccurate. Tank may contain groundwater seepage but no longer pumped or checked.	2
90	157	157.1	400-157.1	N/A	13	unknown	No documentation found detailing contaminated ditch area outside B442, however decided that composite laundry water samples should be taken before discharging to sewer.	-	HRR 1992		2

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91	157	157.2	400-157.2	N/A	12	39	Mention of cleanup, but no documentation. Large cleanup attempt after B444 fire.	-	HRR 1992	Chemical contamination in soils surrounding B444, B447, B439 and B440.	2
92	204	204	400-204	N/A	15	32	not specified	Due to operating temperatures, TCE and freon not expected to remain in unit	HRR 1992		2
93	204	204	400-204	N/A	15	32	not specified	not specified	HRR Update 1996	No hazardous constituents treated since 1988 when U chips processed no longer coated with oils and coolants.	2
94	N/A	N/A	400-800	N/A	IA	unknown	transformer removed. No record of excavation. Sampling of soils in 1991	-	HRR 1998	Sampling of soils around the location all exhibited less that 25 ppm PCB. Proposed for NFA.	2
95	N/A	N/A	400-800	N/A	N/A	unknown	-	Removed in 1987	HRR 1992	Original transformer was known to have leaked. New transformer several feet south of older pad. Concrete berm surrounding old and new pads at ground level.	2
96	N/A	N/A	400-801	N/A	N/A	unknown	-	Removed in 1987. Recommended area should be cleaned again.	HRR 1992	Unknown - 1987	2
97	N/A	N/A	400-802	N/A	N/A	14	not specified	Drums moved to "bull-pen" 903 Pad area in 1956, slab remains	HRR 1992	Additional monitoring conducted in Dec. 1956, revealed contamination spreading due to weather conditions. By Jan. 1957, low-level radioactivity extended to fuel storage tank soutj of B551. PCE used to clean slab.	2
98	N/A	N/A	400-803	N/A	N/A	unknown	Contractor to have cleaned up ditchend taken to landfill	No documentation was found verifying spilled material removed	HRR 1992		2
99	N/A	N/A	400-805	N/A	N/A	not specified	-	Maintenance to repair leak	HRR 1992		2
100	N/A	N/A	400-806	N/A	N/A	1 day	Oil-Dry used	-	HRR 1992	Catalyst determined not to be a hazardous material. Oil-dry disposition not documented. Determined the event not reportable.	2
101	N/A	N/A	400-808	N/A	N/A	1 day	Pump repaired	-	HRR 1992	Di-n-octyl phthalate (DOP) disovered on March 8 pulling through line. Cleanup on March 13 (7 days after repair). Determined from analytical results not RCRA-regulated.	2
102	N/A	N/A	400-809	N/A	N/A	1 day	Cleaned with adsorbent material	-	HRR 1992		2
103	N/A	N/A	400-811	N/A	IA	unknown	concrete berm installed and sampling performed. Transformer removed.	Contaminated soils (230 ppm PCB) were excavated July 1993.	HRR 1998	Remaining soil less than 25 ppm PCB. Proposed for NFA.	2
104	N/A	N/A	400-812	N/A	not specified	1 day	Absorbent material used to contain and recover material. 12-gallons recovered.	Soil affected was recovered, drummed into 8 drums and stored in 90-day accumulation area of B460	HRR Update Quarter 7 (1994)	-	2
105	N/A	N/A	500-900	N/A	N/A	1	-	pad coated with sealant and transformers flushed	HRR 1992	Photographs show staining visible on concrete pad	2
106	N/A	N/A	500-900	N/A	N/A	not specified	not specified	In 1995, 8 yd^3 excavated and sent off-Site for disposal	HRR Update 1996	Dates of occurence "Prior to 1986"	2
107	N/A	N/A	500-901	N/A	N/A	5 days	Transformer 555 flushed	Scheduled for cleanup in 1989	HRR 1992	Smear values ranged from 2.0 - 6.2 ppm PCBs	2
108	N/A	N/A	500-901	N/A	N/A	not specified	not specified	No cleanup performed	HRR Update 1996	Dates of occurance "Prior to 1986"; In 1996, PCB levles reamining in soil were < 10 ppm.	2
109	N/A	N/A	500-902	N/A	N/A	not specified	-	Drained and retrofitted to pad several feet to the South of previous location. Concrete material removed.	HRR 1992	Total volumes listed for the transformer, but not for the spills/leaks.	2
110	N/A	N/A	500-902	N/A	N/A	not specified	not specified	In 1995, 25 yd^3 excavated and sent off-Site for disposal	HRR Update 1996	Dates of occurence "Prior to 1987"	2
111	N/A	N/A	500-903	N/A	N/A	4	-	Leaking drum placed in overpack drum, secondary containment cleaned	HRR 1992	Not clearly defined if cleanup was at the time of incident or some time after.	2
112	N/A	N/A	500-904	N/A	N/A	Prior to 1986, February 1986	-	Scheduled for repair. Retro filled with non-PCB cooling oil in 1987	HRR 1992	Fluid in Transofmers contained 19800 ppm and 298 ppm PCBs, respectively.	2
113	N/A	N/A	500-905	N/A	N/A	not specified	not specified	No cleanup performed	HRR Update 1996	Dates of occurance "Prior to 1986"; In 1996, PCB levles reamining in soil were < 10 ppm.	2
114	N/A	N/A	500-906	N/A	N/A	1 day	Oil-Dry used to absorb water. Some absorbed into asphalt or released into air.	Spill pans now being used during transfers to provide secondary containment.	HRR Update Quarter 4 (1993)	-	2
115	172	172	500-907	N/A	N/A	1 day	Area blocked off, wet vacuum removed liquid, 30-lbs of soil removed followed by 40-lbs soil removed and containerized.	-	HRR Update Quarter 9 (1994)	-	2
116	188, 156	188, 156.1	500-908	N/A	N/A	1 day	oil cleaned up, inside building and rock area outside. 2,800-lbs of rock and 10-lbs of soil removed from NW of B223, 4 drums filled with cleanup material.	-	HRR Update Quarter 12 (1995)	-	2
117	N/A	N/A	600-1002	N/A	N/A	unknown	No documentation found detailing response	No documentation found detailing response	HRR 1992	Leaks and spills may have occurred at site.	2
118	N/A	N/A	600-1002	N/A	N/A	unknown	No documentation found detailing response	No documentation found detailing response	HRR 1992	Leaks and spills may have occurred at site.	2
119	N/A	N/A	600-1002	N/A	N/A	unknown	not specified	Transformer storage no longer occurs at the Site	HRR Update 1996	Pu-239 (unknown origin) also present in soil samples collected in 1991. No documentation found detailing response to spills or releases prior to 1991.	2
120	N/A	N/A	600-1003	N/A	N/A	unknown	No documentation found detailing response	No documentation found detailing response	HRR 1992	-	2
121	N/A	N/A	600-1003	N/A	N/A	unknown	No documentation found detailing response	No documentation found detailing response	HRR 1992	-	2
122	N/A	N/A	600-1003	N/A	N/A	unknown	not specified	In 1995, 47 yd^3 excavated and sent off-Site for disposal	HRR Update 1996	No documentation found detailing fate of constituents	2

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123	120	120.1, 120.2	600-120.1, 600-120.2	N/A	12	7	No documentation found	No documentation found	HRR 1992	No documentation found which provided explanation for elevated readings in the vicinity of these sites	2
124	160	160	600-160	N/A	14	33	-	Decontamination activities. No specifics.	HRR 1992	Unknown contaminated liquids leaked due to rain or melting snow entering boxes	2
125	161	161	600-161	N/A	N/A	21	-	No documentation found that provides details of any soil remediation activities, but may have been removed in early 1970s.	HRR 1992	Oil spread on asphalt	2
126	N/A	N/A	700-1102	N/A	N/A	1	Indication of transformer maintenance. No Indication of cleanup	not specified	HRR 1992	Several transformer oil spills noted during 1986	2
127	N/A	N/A	700-1102	N/A	N/A	unknown	not specified	Transformer moved to new pad several feet North in 1987. In 1995, 146 yd^3 of soil to depth of 15-feet below grade removed below concrete pad. Area ~20ft^2 at bottom of excavation exists contaminated (40-70ppm PCBs). Excavation stoppped when no longer feasible to continue source removal.	HRR Update 1996	"Prior to January 1986". In 1976, Transformer 776-4 drained and refilled with non-PCB silicone oil, but 1985 results indicated PCBs>500ppm.	2
128	N/A	N/A	700-1102	N/A	N/A	unknown	not specified	Transformer moved to a new pad to the North in 1987. 177 yd^3 soil and 10.7 yd^3 concrete excavated to 17' depth, containerized and shipped to California landfill. 20ft^2 of soil remains PCB-contminated. Excavation stopped due to equipment limitations, health, and safety concerns.	HRR Update 1997	Prior to January 1986	2
129	N/A	N/A	700-1102	N/A	N/A	1	Indication of transformer maintenance. No indication of cleanup	not specified	HRR 2000	Remediated from initial PCB contamination of 480 ppm Aroclor-1260 to 70 ppm. Residual contamination is at 17 ft depth. Recommended for No Further Action in 1997, but regulatory agencies want further groundwater samples.	2
130	N/A	N/A	700-1103	N/A	N/A	16	not specified	not specified	HRR 1992	Leaking transformers on southeast part of 707 roof. PCBs detected on ground.	2
131	N/A	N/A	700-1103	N/A	N/A	1 day	not specified	Cleanup on B707 concrete rooftop performed in 1992 to cleanup standard of 100mg/100cm. Transformer 707-1 retrofilled. In 1995, 67 yd^3 of soils shipped to Calif. for disposal.	HRR Update 1996	In 1991, tested for migration from downspout location and a decrease resulted as distance increased. HRR doesn't address all transformers and all concrete pads' outcome.	2
132	N/A	N/A	700-1104	N/A	N/A	1	not specified	4 transformers moved from this site and retrofilled in 1987. No documentation of PCB cleanup	HRR 1992	Leaking transformers west of 708. PCBs detected on ground.	2
133	N/A	N/A	700-1104	N/A	N/A	1	not specified	In 1995, ~21 yd3 soil excavated, containerized and shipped off-Site.	HRR Update 1996	-	2
134	N/A	N/A	700-1105	N/A	N/A	unknown	not specified	2 transformers moved from this site and retrofilled in 1987. No documentation of PCB cleanup	HRR 1992	Leaking transformers with PCBs northeast of 779.	2
135	N/A	N/A	700-1107	N/A	N/A	2 days	"Oil-Dry" absorbent used for both spills.	not specified	HRR 1992	Leaking transformers with PCBs northeast of 779	2
136	N/A	N/A	700-1108	N/A	N/A	45	not specified	not specified	HRR 1992	Nitrates measured in pond N. of 771. PCBs also detected in area (believed to have originated from PAC 700-1112).	2
137	N/A	N/A	700-1111	N/A	N/A	unknown	Transformer replaced (though not known if release ever occurred)	not specified	HRR 1992	No documentation that release ever occurred, but transformer replaced as a precaution	2
138	N/A	N/A	700-1111	N/A	N/A	unknown	not specified	Concrete berm sealed. ~26 yd^3 of soil excavated, containerized an shipped off-Site.	HRR Update 1996	"Prior to 1987".	2
139	N/A	N/A	700-1112	N/A	N/A	3	not specified	Scheduled for cleanup in August 1989.	HRR 1992	Concentration of PCBs in transformer is 807 ppm. Concentration in environment not measured.	2
140	N/A	N/A	700-1112	N/A	N/A	3	not specified	In 1989, scheduled for cleanup, but no documentation found verifying cleanup.	HRR Update 1996	-	2
141	101	101	700-1113	N/A	N/A	1 day	15-lbs of soil removed from wetted area, hose removed and replaced	No further sampling or cleanup scheduled	HRR Update Quarter 11 (1995)	-	2
142	N/A	N/A	700-1114	N/A	N/A	2 days	Hazardous Material cleanup	-	HRR Update 1997	-	2
143	N/A	N/A	700-1115	N/A	N/A	1 day	upon receipt of data, project proceeded.	-	HRR Update 1997	No other documentation of past occurrences found except for 10-15 gallons fuel spilled onto asphalt surface and no migration into soil occurred. UST #16 piping is located 20' north.	2
144	150	150.7	700-1116	N/A	IA	unknown (possibly 1957-1998)	transformer repaired, no sampling of surrounding area	-	HRR 1998	Small stain area, but unknown spill duration/ quantity	2
145	N/A	N/A	700-1117	N/A	IA	unknown	none	none ; soils approved for return to excavation	HRR 1998	Souce and extent of this contamination uncertain. Close to other CCL4 leak (700-118.1)	2
146	163	163.1	700-1209	N/A	8	unknown	not specified	not specified	HRR 1992	Not agreed that this area was even used to wash equipment. No documented release.	2
147	123	123.1	700-123.1	N/A	8	1 day	Temporary dikes constructed to control overflow. Ditch cleaned of visible contamination	not specified	HRR 1992	Oil from spill visible in ponds B-1, B-4, B-5. No abnormal concentrations detected a week later. No materail from spill observed on Pond B-5.	2

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148	123	123.1	700-123.1	N/A	N/A	1 day	not specified	Spill visible in Pond B-1 and held for 3 weeks before release to Great Western Res. Visible contamination in Ninth St. ditch. No documentation found detailing complete removal of release.	HRR Update 1997		2
149	123	123.2	700-123.2	N/A	9	Short-term event	not specified	not specified	HRR 1992	No documentation on fate of constituents. 4050 gallons is the estimated upper limit volume of process waste water released.	2
150	124	124.1, 124.2, 124.3	700-124.1, 700-124.2, 700-124.3	N/A	9	38	Area of spill paved to cover Pu contamination (1981)	not specified	HRR 1992	No VOCs reported. Only nitrates. No discussion of nitrate concentration. Estimated 500 gallons of process waste spilled in 1981 from Tank #66.	2
151	125	125	700-125	N/A	9	37	Area of spill paved to cover Pu contamination (1981)	not specified	HRR 1992	No VOCs reported. Only nitrates. No discussion of nitrate concentration. Estimated 500 gallons of process waste spilled in 1981 from Tank #66.	2
152	126	126.1, 126.2	700-126.1, 700.126.2	N/A	9	31	not specified	not specified	HRR 1992	Tanks overflowed several times prior to 1958. No further documentation regarding fate of contaminants.	2
153	132	132	700-132	N/A	IA	28	not specified	Mention of later cleanup, but no specifics. Tank T-10 emptied, rinsed, sampled, foamed. Tank T-9 active plenum tank for B776 (Process Waste Pit).	HRR Update 1997	Contamination detected in the surface soil, subsurface soil and groundwater. Some contamination believed to be related to IHSS 118.1.	2
154	147	147.1	700-147.1	N/A	9	29	2 yards of soil removed in 1984	not specified	HRR 1992	No report of VOC contamination. Groundwater samples east of where breaks occurred had up to several hundred ppm nitrate. Several documented process waste line breaks (1955, 1959, 1960, 1964, 1971, 1984).	2
155	149	149.1, 149.2	700-149	N/A	9	8	Repair of pipeline in 1973	not specified	HRR 1992	10,000 mg/L nitrate in spilled water from 1980 incident (1,000 gallon process waste leak)	2
156	150	150.1	700-150.1	N/A	8	17	various remedial actions for different events	not specified	HRR 1992	No documentation found which detailed fate of contaminants.	2
157	150	150.3	700-150.3	N/A	8	10	Tunnel sealed. Soil cleanup (mainly for rad contamination)	not specified	HRR 1992	Incidents in Aug., Sept., Dec. 1971 and late 1970s or early 1980s. Process waste may have contained nitrates. No documentation on fate of constituents.	2
158	150	150.5	700-150.5	N/A	8	30	not specified	not specified	HRR 1992	Valve vault overflow with possible oils, solvents, nitric acid	2
159	150	150.7	700-150.7	N/A	8	<1	Oil and gravel removed approximately 2 months after first applied	not specified	HRR 1992	Oil and gravel applied as temporary measure over Pu contamination from May 1969 fire in B776/777	2
160	185	185	700-185	N/A	16	1 day	4 bags of absorbent used to cleanup spill. Material was cleaned up and placed in drums.	not specified	HRR 1992	Forklift fork punctured a drum with TCA on 11/10/86. Approx. 4 gallons went to ground. Cleaned up at that time.	2
161	185	185	700-185	N/A	16	1 day	commericial absorbent cleaned spill	-	HRR Update 1996	Groundwater samples analyzed for TCA nearby indicated no contamination present. Wind dispersion and infiltration transport pathway were eleiminated b/c residual voltized rapidly.	2
162	214	214	700-214	N/A	10	16	Pondcrete cleaned up a time of spills	not specified	HRR 1992	Pondcrete spills, nitrate in surface water	2
163	102	102	800-102	N/A	1	1	not specified	Pit backfilled when disposing operations ceased. Corners of pit marked, though no evidence of marked corners found.	HRR Update 1997	Laboratory analysis detected chlorinated solvents, PAHs, and radionuclides. No doumentation found which verifies existence of this site. Personel interviewed could not recall any dumping	2
164	105	105.1, 105.2	800-105.1, 800-105.2	N/A	1	18	not specified	Later filled with concrete and asbestos	HRR Update 1997	881 Hillside oil leak may have been caused by leakage from these tanks. Flow expected towards Women Creek or SID.	2
165	106	106	800-106	N/A	1	unknown	not specified	not specified	HRR Update 1997	Early 1950s - 1977.	2
166	N/A	N/A	800-1207	N/A	none	4	not specified	not specified	HRR 1992	No documented remedial action, but transformer scheduled for removal by 1988	2
167	N/A	N/A	800-1207	N/A	N/A	3	not specified	Transformer retrofilled w/ non-PCB oil in 1986 or 1987. Pad disposed of in on-Site landfill. ~28 yd^3 soil excavated and disposed off-Site.	HRR Update 1996	-	2
168	N/A	N/A	800-1208	N/A	N/A	unknown	not specified	Based on 1991 data, no further investigation.	HRR Update 1996	-	2
169	N/A	N/A	800-1209	N/A	N/A	unknown	not specified	transformers retro-filled in 1987	HRR 1992	No release to environment documented	2
170	N/A	N/A	800-1209	N/A	N/A	unknown	not specified	Based on 1991 data, no further investigation.	HRR Update 1996	Unknown to 1991.	2
171	N/A	N/A	800-1210	N/A	none	unknown	not specified	transformers removed, retro-filled in 1987	HRR 1992	Utilities personnel indicated that these transformers leaked in past	2
172	N/A	N/A	800-1211	N/A	none	1	not specified	not specified	HRR 1992	Minor oil leak, no PCBs detected	2
173	N/A	N/A	800-1212	N/A	N/A	1 day	Tanks emptied in B866, sump emptied, sludge removed, sump cleaned.	B889 opertions ceased and B885 generating excess chemical waste. Secondary containment for B866 provided by epoxy sealing 2-foot curb and floor and walls of building. Sump sealed off with steel plate and glass window.	HRR Update Quarter 5 (1993)	-	2
174	147	147.2	800-147.2	N/A	IA	2	not specified	Determined site poses no adverse threat.	HRR Update 1997	Positive detects for Ca and Zn.	2
175	178	178	800-178	N/A	15	39	not specified	not specified	HRR 1992	No release to environment documented	2
176	179	179	800-179	N/A	15	22	not specified	not specified	HRR 1992	No release to environment documented	2
177	180	180	800-180	N/A	15	11	not specified	not specified	HRR 1992	No release to environment documented	2

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178	112	112	900-112	N/A	2	10	Soil covered with fill, base course and asphalt	Major remediation planned for Oct. 2002	HRR 1992	4 shallow wells drilled in Nov. 1969; additional wells drilled in 1987.	2
179	112	112	900-112	N/A	2	10	Soil covered with fill, base course and asphalt	Major remediation planned for Oct. 2002	HRR 2000	Primary organic contaminents in sub-surface soils - methylene chloride, PCE, TCE, cis-1,2 dichlorethene	2
180	119	119.1	900-119.1	N/A	2	3	none	none	HRR 1992	Area identified in RCRA 3004(u) as a solvent storage area, though retired employee interviews did not agree.	2
181	119	119.1	900-119.1	N/A	1	3	none	1993 pumping initiated from a recovery well- Water sent to be treated for VOCs. In 1994 21 drums of rad-contaminted soil (55-gallon each) were removed. In 1997, 51 samples from 10 borings found only one contaminent (PCE) above detection, and none close to RFCA	HRR 1998	No good evidence of VOC GW contamination. HRR does not give indication of VOC levels in GW pumped from recovery well. Location is proposed for NFA with exception of some continued monitoring.	2
182	119	119.1	900-119.1	N/A	2	3	none	OU 1 collection well is sampled quarterly. Extraction and treatment of water from collection well continued until Feb 2002. OU 1 French drain breached at lowest point in Sept 2000 to allow water to clow underground to SID	HRR 2001	Only TCE exceeded RFCA Action Level and Standard Framework for Surface Water and Soils (ALF) Tier I AL for Groundwater. (TCE 300ug/L; PCE 30 ug/L; DCE 18 ug/L; CCL4 14 ug/L)	2
183	119	119.1	900-119.1	N/A	2	3	none	no final remidiation decision yet	HRR Update 1996	Area identified in RCRA 3004(u) as a solvent storage area, though retired employee interviews did not agree.	2
184	119	119.1	900-119.1	N/A	1	3	not specified	Area south of 903 Pad cleaned up in 1971 and soild revegetated in 1972.	HRR Update 1997	Groundwater samples had anomalous conc. of U and nitrate in 1974.	2
185	119	119.1	900-119.1	N/A	2	3	none	French Drain installed in 1992 (1,435 ft length) to collect groundwater for treatment	HRR 2000	Groundwater collected by French Drain is consistently below Tier 2 Action Levels. Detections of PCE (0.2 ppb, below MDA) and TCE (1.0 ppb). Decommissioning of the French Drain began on August 31, 2000. Water no longer collected and sampled.	2
186	119	119.2	900-119.2	N/A	2	3	none	none	HRR 1992	Area identified in RCRA 3004(u) as a solvent storage area, though retired employee interviews did not agree.	2
187	119	119.2	900-119.2	N/A	2	3	none	No Action being proposed	HRR Update 1996	Area identified in RCRA 3004(u) as a solvent storage area, though retired employee interviews did not agree.	2
188	119	119.2	900-119.2	N/A	1	3	not specified	Excavated, containerized, storage and disposal of 21, 55-gallon drums with soil. Area south of 903 Pad cleaned up in 1971 and soild revegetated in 1972.	HRR Update 1997	Groundwater samples had anomalous conc. of U and nitrate in 1974.	2
189	127	127	900-127	N/A	9	14	not specified	not specified	HRR 1992	No VOCs reported. Only nitrates. No discussion of nitrate concentration. Leaks detected in 1957 and 1982.	2
190	N/A	N/A	900-1302	N/A	N/A	1 day	No record of cleanup	-	HRR 1992	Estimated 2 gallons of gasoline sprayed into the air or leaked on the ground	2
191	N/A	N/A	900-1306	N/A	N/A	1 day	PCBs were to be cleaned up by outside contractor	not specified	HRR 1992	Large amounts of oil noticed on ground beneath transformers	2
192	N/A	N/A	900-1306	N/A	N/A	unknown	not specified	not specified	HRR Update 1996	"Prior to 1986".	2
193	N/A	N/A	900-1307	N/A	N/A		55-gallon drum of soil and rock was removed.	-	HRR Update 1997	-	2
194	N/A	N/A	900-1309	N/A	2	1 day	Pumps immed. shut down and inspection followed	-	HRR Update Quarter 7 (1994)	Determined soil should not pose an unacceptable risk to human health and environment. Soil was not removed.	2
195	N/A	N/A	900-1309	N/A	2	1 day	Pumps shut down, line repaired	-	HRR Update Quarter 8 (1994)	Released material not directly recoverable. Contaminated soil not removed.	2
196	N/A	N/A	900-1309	N/A	N/A	1 day	Pumps shut down, contingency plan implemented, released material not directly recoverable b/c it soaked into soil	Soil not removed b/c concentrations in soil should not pose an unacceptable rish ot human health and the environment.	HRR Update Quarter 6 (1993)	-	2
197	N/A	N/A	900-1310	N/A	N/A	1 day	-	Pipe connection repaired and material released not directly recoverable b/c soaked into soil. No action taken to recover soil.	HRR Update Quarter 7 (1994)	No action taken to recover soil.	2
198	N/A	N/A	900-1311	N/A	N/A	1	-	Activated sewage sludge treatment system may have replaced the use of septic tank in 1953.	HRR Update Quarter 7 (1994)	-	2
199	192	192	900-1313	N/A	2	1 day	-	Monitored, pumped, sampled, analyzed	HRR Update Quarter 9 (1994)	Source of groundwater contamination identified as the Mound area in OU2. Seep characterization currently in progress. Area warrants further investigation due to nature of contaminents released from seep.	2

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200	101	101	900-1314	N/A	N/A	1 day	Operations immed. ceased, catch pan placed under leaking door, liquid collected with vacuumed and transferred to permitted storage tanks. Soil removed and containerized	Samples collected to ensure adequate cleanup of all contaminated soils	HRR Update Quarter 9 (1994)		2
201	N/A	N/A	900-1315	N/A	N/A	1 day	Valve closed, triple rinsed asphalt, wetted soil removed	Follow up sampling	HRR Update Quarter 10 (1995)		2
202	176	176	900-1317	N/A	N/A	1 day	tarp placed over crate, spilled gravel placed into crate, spilled material cleaned up, samples collected to confirm cleanup		HRR Update Quarter 11 (1995)		2
203	140	140	900-140	N/A	2	14	not specified	not specified	HRR 1992	Indicates some solvents may have been destroyed at this location	2
204	140	140	900-140	N/A	BZ	14	none	sampling and risk assessment	HRR 1998	Sampling efforts have found only slight PCE contamination. This IHSS is located within the boundary of the 903 Pad lip area (IHSS 155)	2
205	140	140	900-140	N/A	2	14	not specified	not specified	HRR 2000	Several organic contaminants of concern detected above RFCA Tier II subsurface soil action levels.	2
206	141	141	900-141	N/A	6	45	not specified	The response to each documented overflow was collection and disposal. Metal buildgs. Constructed around beds to reduce windblown dispersal.	HRR Update 1997	Sludge drying area being investigated as a separate action	2
207	165	165	900-165	N/A	2	9	not specified	In 1973, 200 yars of soil were removed (because of Pu contamination)	HRR 1992	Dilute nitric acid contributed to corrosion of drums	2
208	173	173	900-173	N/A	8	40	not specified	not specified	HRR 1992	No specific spill incidents involving organics. IHSS only because of increased likelihood of spills there, w/ possible rads	2
209	175	175	900-175	N/A	10	20	not specified	not specified	HRR 1992	Only evidence of leak is from stained soil,little info about fate of leaked material	2
210	176	176	900-176	N/A	10	38	not specified	Drums with haz waste removed by 1988, unknown amount, soil cleaned-up	HRR 1992	nitrates wind-blown from solar ponds. Drums stored in yard contained waste oils and unspecified VOCs. Fuel-oil spill in Aug 1988, unknown amt, soil cleaned up	2
211	183	183	900-183	N/A	2	20	glassware triple rinsed, crushed and deposited in Present Landfill		HRR Update 1997		2
212	183	183	900-183	N/A	2	20	not specified	not specified	HRR 2000	No documented release from Bldg 952. Meth chloride (2 ppb) and acetone (15 ppb) detected in borehole 12791. These chemicals were not retained in OU2 RFRI.	2
213	183	183	900-183	N/A	BZ	20			HRR Update 2002	No documentation found detaining releases to building or surrounding soil.	2
214	184	184	900-184	N/A	8	25	not specified	not specified	HRR 1992	No record of a specific release to the environment	2
215	213	213	900-213	N/A	10	15	pondcrete release area decontaminated with water and vacuumed	not specified	HRR 1992	Pondcrete has high nitrates, trace VOCs. Elevated levels of nitrates observed in runoff from Pad	2
216	N/A	N/A	N/A	N/A	N/A	not specified	-	Removal of a section of floor	HRR 1992	Incident not clearly described. Need to locate reference document	2
217	N/A	N/A	N/A	N/A	N/A	not specified	not specified	not specified	HRR 1992	One incident in 1953 and discussion of routine discard of waste this way in "early years"	2
218	N/A	N/A	N/A	N/A	not specified	22			HRR Update 2002	No documentation found detailing dates of occurrence.	2
219	N/A	N/A	N/A	16	N/A	not specified	No record of cleanup	No record of cleanup	HRR 1992	-	2
220	N/A	N/A	N/A	N/A	N/A	1 month	not specified	not specified	HRR 1992	-	2
221	N/A	N/A	N/A	N/A	N/A	1 month	not specified	Preliminary characterization of 771 UBC 8/30/01. Nitrate and VOCs exceed Tier II in GW at 4 locations. No definitive point sources identified.	HRR 2001	-	2
222	N/A	N/A	N/A	47	N/A	2 days	No record of cleanup	No record of cleanup	HRR 1992	-	2
223	N/A	N/A	N/A	43	N/A	1 day	No record of cleanup	No record of cleanup	HRR 1992	-	2
224	N/A	N/A	N/A	N/A	N/A	Single incident- 1 day	not specified	not specified	HRR 1992	Incident not clearly described. Need to locate reference document	2
225	N/A	N/A	N/A	18	N/A	1 day	contaminated ground covered with gravel	-	HRR 1992	-	2
226	N/A	N/A	N/A	N/A	not specified	20		B889 slab, footer walls, footers, sumps, tanks, waste lines removed and packaged for disposal	HRR Update 2002	Dates of occurrence state 1969 - late 1980s.	2
227	N/A	N/A	N/A	53	N/A	1 day	No record of cleanup	No record of cleanup	HRR 1992	-	2
228	N/A	N/A	N/A	9	N/A	unknown	Drum removed. Other response not documented	-	HRR 1992	-	2
229	N/A	N/A	N/A	61	N/A	unknown	No record of cleanup	No record of cleanup	HRR 1992	-	2
230	N/A	N/A	N/A	41	N/A	9	No record of cleanup	No record of cleanup	HRR 1992	Little info about response or fate of leaked material	2

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231	N/A	N/A	N/A	52	N/A	1 day	No record of cleanup	No record of cleanup	HRR 1992	-	2
232	N/A	N/A	N/A	8	N/A	1 day	sand spread on road surface to soak up. Sand to be picked up next day, but no record.	-	HRR 1992	-	2
233	N/A	N/A	N/A	22	N/A	1 day	No record of cleanup	No record of cleanup	HRR 1992	-	2
234	N/A	N/A	N/A	6	N/A	1 day	reported, but no record of remediation	-	HRR 1992	-	2
235	N/A	N/A	N/A	1	N/A	1 day	Cleaned off equipment, but allowed to soak into ground	-	HRR 1992	-	2
236	N/A	N/A	N/A	13	N/A	not specified	compressor removed leaving behind oil stained concrete. No reocord of further cleanup.	-	HRR 1992	-	2
237	N/A	N/A	N/A	11	N/A	1 day	Liquid captured by concrete pad was cleaned up. No record of cleanup of surrounding release	-	HRR 1992	-	2
238	N/A	N/A	N/A	45	N/A	1 day	cleanup documented to have occurred, but no details	-	HRR 1992	East of 904 Pad	2
239	N/A	N/A	N/A	12	N/A	1 day	immediately contained with "oil dry". No record of final disposition.	-	HRR 1992	-	2
240	N/A	N/A	N/A	2	N/A	1 day	gasoline saturated soil was excavated and removed to a drum	-	HRR 1992	-	2
241	N/A	N/A	N/A	5	N/A	1 day	No record of cleanup	No record of cleanup	HRR 1992	-	2
242	N/A	N/A	N/A	27	N/A	1 day	No record of cleanup	-	HRR 1992	East Access Road	2
243	N/A	N/A	N/A	7	N/A	1 day	"Releases material secured to be disposed of"	-	HRR 1992	Poor description of remedial action	2
244	N/A	N/A	N/A	10	N/A	1 day	Haz Mat response team responded and "corrected the situation"	-	HRR 1992	-	2
245	N/A	N/A	N/A	21	N/A	1 day	leak stopped and spill was "cleaned up and disposed of properly"	-	HRR 1992	-	2
246	N/A	N/A	N/A	23	N/A	1 day	HAZMAT response team applied "Oil-Dri", then packaged and removed material to 334.	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
247	N/A	N/A	N/A	24	N/A	1 day	HAZMAT response team applied "Oil-Dri", then packaged and removed material to 334.	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
248	N/A	N/A	N/A	25	N/A	1 day	HAZMAT response team applied "Oil-Dri", then packaged and removed material to 334.	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
249	N/A	N/A	N/A	26	N/A	1 day	HAZMAT response team removed 1.5 cubic feet of contaminated material.	-	HRR 1992	HAZMAT team indicates no likely release to environment. Location area is the windsite.	2
250	N/A	N/A	N/A	28	N/A	1 day	1.2 CF of contaminated material removed by HAZMAT team	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
251	N/A	N/A	N/A	29	N/A	1 day	2 CF of waste material removed	-	HRR 1992	Report indicates no likely release to environment	2
252	N/A	N/A	N/A	30	N/A	1 day	3 CF of waste material removed	-	HRR 1992	Report indicates no likely release to environment	2
253	N/A	N/A	N/A	31	N/A	1 day	1.5 CF of contaminated material removed by HAZMAT team	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
254	N/A	N/A	N/A	32	N/A	1 day	75 CF of contaminated material removed	-	HRR 1992	Report indicates no likely release to environment	2
255	N/A	N/A	N/A	33	N/A	1 day	1 CF of contaminated material removed	-	HRR 1992	Report indicates no likely release to environment	2
256	N/A	N/A	N/A	34	N/A	1 day	4 lbs of contaminated material removed by HAZMAT	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
257	N/A	N/A	N/A	35	N/A	1 day	No cleanup because material evaporated before discovery	-	HRR 1992	-	2
258	N/A	N/A	N/A	36	N/A	1 day	0.5 CF of contaminated material removed by HAZMAT	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
259	N/A	N/A	N/A	37	N/A	1 day	40 gallons of soil removed	-	HRR 1992	Report indicates no likely release to environment	2
260	N/A	N/A	N/A	38	N/A	1 day	3 CF of waste material removed	-	HRR 1992	Report indicates no likely release to environment	2
261	N/A	N/A	N/A	39	N/A	1 day	1 CF of contaminated material removed by HAZMAT	-	HRR 1992	HAZMAT team indicates no likely release to environment	2
262	N/A	N/A	N/A	40	N/A	1 day	21 CF of contaminated material removed	-	HRR 1992	Report indicates no likely release to environment	2
263	N/A	N/A	N/A	48	N/A	1 day	Cleaned by Site Haz Mat team	-	HRR 1992	-	2
264	N/A	N/A	N/A	49	N/A	unknown	1 CF of soil removed and leak fixed	-	HRR 1992	-	2
265	110	110	NE-110	N/A	2	13	not specified	not specified	HRR 1992	T-2 thru T-11 125,000 kg of sludge disposed during 1955-1968	2
266	110	110	NE-110	N/A	2	13	not specified	Source removal action completed in summer 1996, excavating and removing VOCs from soil using low-temperature thermal desorption	HRR 2000	Treated soils were returned to the excavation. Clean-up levels were 11 ppm for CCl4 and 11.5 ppm TCE. Detectable VOCs in excavation verification samples: 1.8 ppm CCl4 and 0.74 to 6.2 ppm TCE.	2

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267	111	111.1	NE-111.1	N/A	2	2	not specified	2094 yd^3 VOC contminated amterial removed in 1996. ~150 yd3 of debris, crushed drums and junk removed. ~250 yd3 of soil exceeded "Tier II put back" levels was segregated and placed over a geotextile liner and covered.	HRR Update 1996	-	2
268	111	111.1, 111.2, 111.3, 111.4, 111.5, 111.6, 111.7, 111.8	NE-111.1, NE-111.2, NE-111.3, NE-111.4, NE-111.5, NE-111.6, NE-111.7, NE-111.8	N/A	2	13	not specified	not specified	HRR 1992	T-2 thru T-11 125,000 kg of sludge disposed during 1955-1968	2
269	N/A	N/A	NE-1401	N/A	N/A	2 days	RFP shutoff flow to line	-	HRR 1992	no documentation list fate of constituents to environment	2
270	N/A	N/A	NE-1402	N/A	N/A	1 day	contaminated asphalt removed	-	HRR 1992	Commercial truck to pick up PCB wastes leaking before entering site	2
271	N/A	N/A	NE-1403	N/A	N/A	not specified	Oil-Dri contained and removed	-	HRR 1992	released to asphalt due to defective fuel level gage	2
272	N/A	N/A	NE-1404	N/A	N/A	1 day	Approx. 1.5 yards of contaminate soil excavated and removed. Absorbent booms used on pond B-2.	N/A	HRR 2000	Spill area cleaned up until no visual evidence or odor contamination was present	2
273	N/A	N/A	NE-1404	N/A	N/A	1 day	Approx. 1.5 yards of contaminate soil excavated and removed. Absorbent booms used on pond B-2.	N/A	HRR Update Quarter 2 (1992)	Analytical data for TCLP volatiles is in 1992 HRR quarterly updates 1-6. Spill area cleaned up until no visual evidence or odor contamination was present	2
274	N/A	N/A	NE-1405	N/A	2	2	Cleanup with absorbent material	Soil excavated and filled 17 gray drums.	HRR Update Quarter 7 (1994)	17 drums await off-Site shipment to incineration facility.	2
275	N/A	N/A	NE-1406	N/A	2	1 day	Desiccant immediately applied to area. All wetted material removed and containerized.	-	HRR Update Quarter 4 (1993)	-	2
276	N/A	N/A	NE-1407	N/A	2	1 day	Soil within spill area diked to limit the area of the release.	Contaminant concentrations in soil should not pose unacceptable risk.	HRR Update Quarter 4 (1993)	-	2
277	N/A	N/A	NE-1408	N/A	2	1 day	Desiccant immediat. applied to area to absorb water and prevent spreading. Wet dirt and layer of dry dirt were removed from area containertzed, and managed as investigation derived material.	-	HRR Update Quarter 7 (1994)	-	2
278	N/A	N/A	NE-1409	N/A	not specified	1 day	no release	no release	HRR Update Quarter 7 (1994)	No constituents released to environment	2
279	N/A	N/A	NE-1410	N/A	2	2 days	Absorbed with Oil-Dri for both incidents. Soil removed.	-	HRR Update Quarter 7 (1994)	-	2
280	N/A	N/A	NE-1411	N/A	2	1 day	Immediate response to contain leak. Haz-Mat removed soil and placed it in barrels.	-	HRR Update Quarter 7 (1994)	-	2
281	142	142.1, 142.2, 142.3, 142.4	NE-142.1, NE-142.2, NE-142.3, NE-142.4	N/A	6	not specified	not specified	not specified	HRR Update 1997	In 1950s, discharges from B771 routinely made it to the A-Series drainage. In 1971, remediation of contaminated soil at B771 began (PAC 700-143).	2
282	142	142.12	NE-142.12	N/A	6	18	not specified	occasional cleaning to reduce bottom sediments	HRR Update 1996	IHSS dates show 1978-present; sediment data presented as Risk-Based Concentrations (RBCs) also	2
283	142	142.5, 142.6, 142.7, 142.8, 142.9	NE-142.5, NE-142.6, NE-142.7, NE-142.8, NE142.9	N/A	6	not specified	not specified	not specified	HRR 1992	Cause not identified	2
284	166	166.1, 166.2, 166.3	NE-166.1, NE-166.2, NE-166.3	N/A	6	uncertain	uncertain	uncertain	HRR 1992	uncertain, sometime between 1955 - 1964, sludge likely from B995	2
285	166	166.1, 166.2, 166.3	NE-166.1, NE-166.2, NE-166.3	N/A	6	uncertain	uncertain	uncertain	HRR Update 1996	IHSS dates show prior to 1964 and 1970; sediment data presented as Risk-Based Concentrations (RBCs) also	2
286	167	167.2, 167.3	NE-167.2, NE-167.3	N/A	7	19	none specified	none specified	HRR Update 1996	-	2
287	216	216.1	NE-216.1	N/A	6	1	not specified	not specified	HRR Update 1996	North area opened in 1989 b/c of excessive runoff from existing east spray fields. Closed shortly after opening due to excessive runoff from a new spray field located top of hall between A-Series and B-Series drainages (East of protected area fence).	2
288	216	216.1, 216.2, 216.3	NE-216.1, NE-216.2, NE-216.3	N/A	6 and 2	21	not specified	not specified	HRR 1992	Occurred 1979-1990	2
289	216	216.2, 216.3	NE-216.2, NE-216.3	N/A	BZ	11	not specified	not specified	HRR Update 1997	-	2

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REFERENCE NUMBER	IHSS INTEGER (for database search)	IHSS IDENTIFIER	PAC REFERENCE NUMBER	PIC REFERENCE NUMBER	OU REFERENCE NUMBER	DURATION (years)	REMEDIATION ACTION At Time of Incident	REMEDIATION ACTION Time After Incident	REFERENCE DOCUMENT	COMMENTS	PRIORITY FACTOR
290	N/A	N/A	NW-1500	N/A	10	1 day	Soil excavated after sampling.	Drums remain at location until all data reviewed.	HRR Update Quarter 7 (1994)	PU&D Yard Unit dates of operation 1974-present.	2
291	114	114	NW-1502	N/A	7	1 day	-	100-lbs material suspected to be contaminated recovered and disposed of properly.	HRR Update Quarter 7 (1994)	Present Landfill, Sanitary Landfill in operation since 1968	2
292	N/A	N/A	NW-1503	N/A	not specified	1 day	Immediately recovered and drummed.	-	HRR Update Quarter 7 (1994)	Determined no potential threat to human or environment.	2
293	114	114	NW-1504	N/A	not specified	1 day	75-lbs of Oil-Dri used to cleanup. Material placed in drum and transferred to the sanitary landfill. Half of material lost during truck crushing. Drum recovered and waits decision for appropriate disposal location.	-	HRR Update Quarter 7 (1994)	Thorositene considered ignitable in liquid form.	2
294	170	170	NW-170	N/A	10	18	not specified	not specified	HRR 1992	Occurred 1974-Present, no additional documentation found to detail releases to environment	2
295	170	170	NW-170	N/A	BZ	unknown	none; sampling of soil and GW	-	HRR 1998	Uncertain release date, souce, quantity, contents. No strong indication of highly contaminated GW or soils.	2
296	170	170	NW-170	N/A	10	18	not specified	Field Scale treatability Study using HRC (Hydrogen Release Compound)- Slow release of lactic acid upon hydration stimulates rapid degradation of chlorinated VOCs. 800lbs of HRC introduced February 2001.	HRR 2001	Tetrachloroethene is primary contaminant, with the highest GW concentration observed to be 1,700 ug/L.	2
297	174	174a, 174b	NW-174a, NW-174b	N/A	10	18	not specified	not specified	HRR 1992	1974-Present, documented visual staining on ground surface, no documentation of leaks or spills found	2
298	203	203	NW-203	N/A	7	1	leaking drum in cargo observed	Year 1988	HRR 1992	"A total of 384 55-gallon drums could be stored...Presence or absence of these constituents is unknown. No release to the environment occurred because of this incident."	2
299	203	203	NW-203	N/A	7	1	not specified	drum that leaked PCBs in 1988 was placed in overpak drum and debris placed in a waste drum	HRR Update 1996	-	2
300	142	142.10, 142.11	SE-142.10, SE-142.11	N/A	5	37	not specified	not specified	HRR 1992	1955-Present	2
301	142	142.10, 142.11	SE-142.10, SE-142.11	N/A	5	42	not specified	Soil removal, capping, grass seeding, traffic restriction	HRR Update 1997	-	2
302	N/A	N/A	SE-1600	N/A	-	9	not specified	not specified	HRR 1992	1955-1964	2
303	115	115	SW-115	N/A	5	16	-	some soil removed/recovered from landfill	HRR 1992	1952-1968	2
304	196	196	SW-196	N/A	16	9	not specified	not specified	HRR 1992	1955-1964, a 1974 reference refers to Woman Creek receiving backwash discharge	2
305	N/A	N/A	000-121	N/A	N/A	31	tank was emptied, rinsed, and foamed in 1996	accelerated action included removal of Tank 40 and debris associated with the upper vault was disposed of as sanitary waste	HRR Update 2002	sampling results from the soil beneath the removed tank show all contaminant concentrations are less than RFCA Tier II Action Levels	3
306	172	172	000-172	N/A	IA	1 day	Road closed. Various washing procedures, some removal. Soil removal in area of 774 dock.	-	HRR 1998	Though the incident covered a large area, very small amounts of organics were released. Further, cleanup efforts are expected to have removed most of the contamination in the 774 dock area. The incident is proposed for NFA.	3
307	N/A	N/A	000-502	N/A	N/A	1 day	sample of water was taken on day of event (results indicate that CLP volatiles are comparable to analytical results taken previously)	pipe connection repaired (spill not recoverable because it had soaked into the soil), analytical results forwarded to EPA and CDPHE	HRR Update Quarter 3 (1993)	No action was taken to immediately recover the material, however, "map generation of spill area and survey coordinates are in progress".	3
308	148	148	100-148	N/A	13	22	Unknown	sumps and process waste lines were excavated and packaged for disposal/samples indicated all contaminant concentrations were less the RFCA Tier II ALs	HRR Update 2002	None	3
309	N/A	N/A	100-603	n/a		1 day	Earthen berms constructed. Sampling performed.	Sampling in 2000. VOCs and SVOCs below MDL.	HRR 2001	Proposed for NFA.	3
310	N/A	N/A	100-603	N/A	N/A	1 day	release was contained, potentially contaminated rainwater was neutralized, pumped and treated at Building 374/samples were collected, evaluated and documented	in late 2000, subsurface soil samples were collected and analyzed and reported concentrations were significantly below the RFCA Tier II ALs	HRR Update 2002	revised PAC narrative has been rewritten to include clarification and incorporate new data	3
311	N/A	N/A	100-607	N/A		30	sampling conducted -1984, PCBs in cooling oil below EPA limits, so no corrective actions taken	January 1988, gravel lining in secondary containment removed and footing drain grouted closed-August 1988, transformer cleaned and repaired-September 188, retrofitted with non-PCB-containing oil. Samples collected in 1991 by Industrial Hygiene group were analyzed and no PCB contamination identified.	HRR 2001	Building 111 is undergoing D&D, sampling was conducted, a package and report was completed and approved by the regulatory agencies.	3

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REFERENCE NUMBER	IHSS INTEGER (for database search)	IHSS IDENTIFIER	PAC REFERENCE NUMBER	PIC REFERENCE NUMBER	OU REFERENCE NUMBER	DURATION (Years)	DIATION ACTION At Time of Incident	Time After Incident	REFERENCE DOCUMENT	COMMENTS	PRIORITY FACTOR
312	N/A	N/A	100-608	N/A	IA	unknown	unknown	-	HRR 1998	Time of release and cause of release unclear. Response action unclear. Proposed for NFA based on volume and release to asphalt	3
313	N/A	N/A	100-609	N/A	N/A	5+	surface soil samples were collected from six sampling locations beneath the incinerator concrete slab and analyzed	accelerated action objectives were developed and described in ER RFCA Standard Operating Protocol Notification #02-01	HRR Update 2002	no further action at this time	3
314	181	181	300-181	N/A	IA	2	not specified	not specified	HRR Update 1997	No other documentation of spills or leaks found. No other documentation found detailing response to operation.	3
315	212	212	300-212	N/A	15	12	not specified	not specified	HRR Update 1997	No documentation found detailing a release from Room 3420	3
316	N/A	N/A	300-712	N/A	N/A	1 day	Spill absorbed by absorbent material and packaged.	-	HRR Update Quarter 7 (1994)	Determined no potential threat to human or environment.	3
317	N/A	N/A	400-814	N/A	N/A	1 day	Spill absorbed by Oil-Dri and periodic inspections followed	-	HRR Update Quarter 8 (1994)	-	3
318	N/A	N/A	500-906	N/A	N/A		oil-dry absorbent used to absorb the water and was managed as a RCRA-regulated hazardous waste.	soil sampled in April 2002 confirm VOCs did not reach the underlying soil horizon	HRR Update 2002	no further action	3
319	N/A	N/A	600-1001(a)	N/A	N/A	unknown	Soil excavated and cleaned up	N/A	HRR 2000	Two 5-gal. Buckets with oil/water mixure were found west of 663. Buckets overflowed and stained ground. Positive VOC results detected in water, but all undetected in soil.	- 3
320	117	117.3	600-117.3	N/A	13		-	Asphalt removed	HRR 1992	Glove box transport/removal was source of oil leak	3
321	189	189	600-189	N/A	IA	44	two containers of sodium bicarbonate to used to neutralize Sept 89 spill; Fire Department washed down, diluted, and neutralized acid with sodium bicarbonate following June 1986 spill	March 3, 1994 surfical sampling conducted at five locations and acid tanks removed on September 29, 1996	HRR 2001	due to small amounts of acid spilled and the neutralization effect over time, the cumulative hazard indices for noncarcinogenic health effects are expected to be 0.01 or less and no adverse noncancer health effects are expected under the exposure conditions evaluated.	3
322	N/A	N/A	700-1102	n/a		unknown	Transformer moved to new concrete pad in 1987. Original pad scabbled to remove surface contamination.	177 cubic yards excavated and shipped to California in 1996.	HRR 2001	Below excavation (at 17-ft), some soil contamination remains (~70 ppm PCB), but no action taken. Groundwater samples showed no detectable PCBs. No indication of mobilization	3
323	N/A	N/A	700-1108	N/A	N/A	30	flow was stopped to broken process waste line thereby stopping the leak	FIDLER survey conducted when soil dried to determine contamination, broken waste line excavated/problem identified as loose flange	HRR Update 1999	PCB contamination is localized within the study area and does not appear to be mobile/intermittent monitoring and evaluation to assess water quality	3
324	N/A	N/A	700-114A, 700-1114B	N/A	N/A	2 days	thorough cleanup performed by RFETS Fire Dept using rags for the asphalt surface and containerized in on 55 gallon drum of soil	55 gallon drum of soil and associated cleanup waste removed and transported to a RCRA Hazardous Waste Management Unit	HRR Update 2002	no further action	3
325	123	123.1	700-123.1	N/A	8	1 day	Temporary dikes constructed to control overflow. Ditch cleaned of visible contamination	not specified	HRR 2000	Sampling done for this IHSS had no detections except for benzo(a)pyrene - present in sample but below MDL. Recommendation for No Further Action at this IHSS.	3
326	150	150.5	700-150.5	N/A	8	30	not specified	not specified	HRR 1998	Valve vault overflow with possible oils, solvents, nitric acid. Not a distinct incident from IHSS 123.1 and 123.2, so it is proposed as NFA to clarify the redundancy.	3
327	178	178	800-178	N/A	15	43	no known release	no known release	HRR Update 1996	-	3
328	179	179	800-179	n/a	15	28	none	none	HRR 2001	No indication of spills. Listed based on former use as storage area.	3
329	179	179	800-179	N/A	15	25	no known release	no known release	HRR Update 1996	-	3
330	180	180	800-180	n/a	15	17	none	none	HRR 2001	No indication of spills. Listed based on former use as storage area.	3
331	211	211	800-211	N/A	N/A	15	no known release	no known release	HRR Update 1996	-	3
332	N/A	N/A	900-108	N/A	BZ	20	in October 1982, drum punctured during routine weed cutting in Trench 1 area was excavated and transferred to size reduction (similar event involving two drums may have occurred in same year)	excavation phase of source removal action initiated 6/10/98, completed 8/20/98	HRR Update 1999	Excavated trench length was 230 feet with 160 drums removed and to remain in intermin storage until a treatment process is identified and waste can be treated for off-Site disposal. Using clean soil stockpile, Trench 1 sucessfully remediated in summer of 1998	3
333	N/A	N/A	900-1308	N/A	N/A	1 day	All of wetted soil removed same day	Plant practice changed to refuel only in non-IHSS locations on concrete of asphalt	HRR 2001	No indication of remaining contamination after cleanup.	3
334	N/A	N/A	900-1308	N/A	N/A	1 day	Contaminated soil excavated and drummed, drum placed in B331	-	HRR Update Quarter 6 (1993)	-	3
335	N/A	N/A	900-1309	N/A	900	1 day	water was pumped to and treated at OU2 Field Treatability Unit for volatile organics, soluble metals and radioactive constituents	sampling was performed weekly closest to the time of the incident, risk assessment completed January 7, 1994 and no further action recommended	HRR Update 1999	N/A	3
336	N/A	N/A	900-1311	N/A	900	During 1952	installed a mixing box and temporary chlorinator for the effluent of the septic tank	samples taken at two points, the flume coming our of the septic tanknear Building 991 and the first pond below the septic tank	HRR Update 1999	soil samples collected identified no contaminant source, therefore no further action recommended	3
337	N/A	N/A	900-1312	N/A	900	1 day	operator shut down inlet pumps and de-energized immedately, repairs were made and system back in normal operation within 6 hours	contaminant source not identified from soil samples collected at time of incident, therefore "No Further Action" recommended	HRR Update 1999	soil samples collected identified no contaminant source, therefore no further action recommended	3

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REFERENCE NUMBER	IHSS INTEGER (for database search)	IHSS IDENTIFIER	PAC REFERENCE NUMBER	PIC REFERENCE NUMBER	OU REFERENCE NUMBER	DURATION (Years)	[illegible]DIATION ACTION: At Time of Incident	[illegible]DIATION ACTION: Time After Incident	REFERENCE DOCUMENT	COMMENTS	PRIORITY FACTOR (see end notes-page 28)
338	N/A	N/A	900-1313	N/A	900	1 day	upon discovery, water sampled for VOCs and pumped to the OU-2 treatment plant	contaminant source not identified from soil samples collected at time of incident, therefore "No Further Action" recommended	HRR Update 1999	soil samples collected identified no contaminant source, therefore no further action recommended	3
339	N/A	N/A	900-1318	N/A		1 day	valve tightened and contaminated soil removed in drum	-	HRR 1998	This PAC was inadvertently numbered as 900-1307 in the 1997 HRR.	3
340	N/A	N/A	900-1318	N/A	2	1 day	soil removed	N/A	HRR 2000	VOCs historically detected in SW-59 seep water, but only 1 pint released to soil.	3
341	154	154	900-154	N/A	N/A	1	unknown	site was "removed" in 1970s	HRR Update 1999	None	3
342	210	210	900-210	N/A	IA	2	-	All hazardous waste removed from unit by 1988	HRR Update 1997	No documentation found detailing specific releases from drums stored in cargo container	3
343	N/A	N/A	N/A	N/A	N/A	unknown	not specified	Remediation scheduled for March 1993	HRR Update Quarter 2 (1992)	Transformer located near southwest corner of B-443	3
344	110	110	NE-110	N/A	BZ	4	N/A	Approximately 1,706 cubic yards of volatile organic compound-contaminated material was removed fro Trench T-3 and treated	HRR Update 2002	source removal is considered complete/clarification regarding why an original HRR (DOE1992) reference pertaining to 2,400 gallon of lathe coolant was deleted	3
345	142	142.8	NE-1404	N/A	6	1 day	berm build around pump and tank; absorbent booms and pillow used in pond B-2; soil excavated in area of spill and removed in drums	-	HRR 1998	Spill was cleaned up in a timely manner. Proposed for NFA.	3
346	142	142.8	NE-1404	N/A	6	1 day	pump taken out of service, an estimated 200 pounds of soil and absorbent boom material suspected to be contaminated was recovered from the spill area and containerized	area declared a RCRA 90 day accumulation area until analytical data received on October 29, 1992 and notification made to ONC, NRC, CDPHE and the State Oil Inspector	HRR Update Quarter 3 (1993)	Reference attached to IHSS supplied analytical data for TCLP Volatiles	3
347	N/A	N/A	NE-1405	N/A	2	1 day	absorbent material applied and soil excavated until no sign of contamination (17 drums)	-	HRR 1998	Spill was cleaned up in a timely manner. Proposed for NFA.	3
348	N/A	N/A	NE-1405	N/A	2	1 day	release was cleaned up with absorbent material	excavated until all indication of fuel presence was gone and seventeen gray drums were filled the following day with soil contaminated by diesel fuel	HRR Update Quarter 4 (1993)	Seventeen drums of sil awaits off-site shipment to an incineration facility. NE-1405 previously reported as NE-1404.	3
349	N/A	N/A	NE-1406	N/A	BZ	unknown	sampling	-	HRR 1998	Uncertain release data. Proposed for NFA.	3
350	N/A	N/A	NE-1406	N/A	N/A	unknown	soil samples collected int the area in which the atypical soil material was identified	the area in which the material is located was cordoned off to restrickt access and evaluation continued	HRR Update Quarter 4 (1993)	Evaluations of area continuing	3
351	N/A	N/A	NE-1407	N/A	2	1 day	pump was turned off, and berm constructed to contain the spill area	characterization samples collected on June 25, 2002	HRR Update 2002	analytical results indicate potential contaminant concentrations were less than RFCA Tier II Action Levels	3
352	N/A	N/A	NE-1408	N/A	2	1 day	soil removed	N/A	HRR Update 1999	No VOC detects in surface soil. Results from Well 3687 had max. concentration of 98 ppb (TCE), 0.87 ppb (CCl4), 1.1 ppb (TCE), 1.044 ppb (1,1 DCE) and 1.1 ppb CHCl3 (chloroform).	3
353	N/A	N/A	NE-1409	N/A	N/A	1 day	Water pumped to portable tanker	N/A	HRR 2000	Released only to secondary containment, not to environment	3
354	170	170	NW-1500	N/A	BZ	1 day	Effected soil was excavated and containerized	-	HRR 1998	Recommended for NFA	3
355	170	170	NW-170	N/A	Buffer Zone	20	surface and subsurface soil analytical data collected	monitoring indicates no known or potential surface water impacts	HRR Update 1999	PCE not detected in soil samples from boreholes indicate a residual source in excess of action levels does not remain.	3
356	170	170	NW-170	N/A	BZ	20	95% of spilled powder was recovered and analyzed/rainwater in the drums was disposed of in accordance with Site waste procedures	assessment of environmental contamination initiated and a pre-remedial investigation conducted to assess VOCs in the subsurface soil	HRR Update 2002	based on the analytical results from the pre-remedial investigation, a VOC contaminant source was not identified	3
357	174	174A, 174B	NW-174A, NW174B	N/A	Buffer Zone	20	rainwater was disposed of in accordance with Site waste procedures, drum decontamination procedures implemented	visual monitoring of the drum and dumpster storage area was conducted periodically	HRR Update 1999	trichlorotrifluoroethane??? Monitoring indicates there are no known or potential surface water impacts	3
358	114	114	NW-177	N/A	7	1 day	EPA and CDPHE notified, and an estimated 100 pounds of material suspected to be contaminated were recovered from the landfill release location and disposed of properly	"Any material not recovered will be remediated with the landfill as part of Operable Unit 7."	HRR Update Quarter 3 (1993)	This release does not add additional scope or cost variables for incorporation into OU#7 and will be incorporated under existing work plans.	3
359	203	203	NW-203	N/A	BZ	unknown (operated from 1986-1988)	sampling	-	HRR 1998	soil gas results inconclusive. Proposed for NFA. This IHSS overlaps with IHSS 114.	3
360	133	133.1, 133.2, 133.3, 133.4	SW-133.1, SW-133.2, SW-133.3, SW-133.4	n/a	5	16	Sampling and marking in 1953, 1954, 1970	-	HRR 2001	Not expected to be a source of VOCs because: (1) No VOCs would survive incinerator; (2) No VOCs detected in subsequent sampling; (3) Result were near detection limits and may be indicative of lab problem	3
361	133	133.5	SW-133.5	n/a	5	16	-	-	HRR 2001	Not expected to be a source of VOCs because: (1) No VOCs would survive incinerator; (2) No VOCs detected in subsequent sampling; (3) Result were near detection limits and may be indicative of lab problem. Also, no contamination in surface soils	3
362	133	133.5	SW-133.5	N/A	5	16	not specified	not specified	HRR Update 1997	Ash placed in trenches to the South and Southeast.	3
363	N/A	N/A	400-811	N/A	N/A	unknown	upon discovery, transformer taken out of service and DOE notified	contaminated soils are to be remediated under CERCLA cleanup standards to 1 ppm to begin in early March	HRR Update Quarter 3 (1993)	"Site location map and analytical data from soil samplin, wipe sampling and analysis of the present oil is enclosed with this update."	2
364	152	152	600-152	N/A	13	37	50 gal spill scraped up and disposed in landfill	not specified	HRR 1992	Released oil confined to ditches and open area	
365	N/A	N/A	600-1210	N/A	N/A	unknown	not specified	Transformers retrofilled and relocated several feet of the north and placed on new concrete pad w/ berms.	HRR Update 1996	Data not clear if represents old location or new location.	
366	112	112	900-112	N/A	BZ	10	in 1964 drums were noted as leaking during routine handling operations, contents of leaking drums transferred to new drums and area fenced to restrict access	from 1968-1970, some contaminated material removed, surrounding area regraded, and covered with base coat material and asphalt cap	HRR Update 1999	PCE, CC14, cis-1, DCA, and TCE in varying concentrations are found in collected groundwater samples	

I (or suspected > 100 gal.)
I (or suspected < 100 gal.)

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Table C-1
Modeled Parameter Ranges
(Report Section 6)

PSA No.	Chain Modeled	Dispersivity (m^2/day)			Sorption Coefficient (L/mg)				Porosity			Degradation (day^{-1})			
		Low Values	Mod-erate	High Values	Sorption Analyte	Low Values	Moderate	High Values	Low Values	Mod-erate	High Values	Degradation Analyte	Low Values	Mod-erate	High Values
2 North/ 6 and 7	CCl_4	5	10	20	CCl_4	1.8×10^{-8}	1.8×10^{-7}	3.5×10^{-7}	0.05	0.1	0.2	CCl_4	0.00004	0.0004	0.004
					CCl_3	1.9×10^{-9}	1.9×10^{-8}	3.8×10^{-8}				CCl_3	0.00003	0.0003	0.003
					CCl_2	3.0×10^{-10}	2.8×10^{-9}	2.0×10^{-9}				CCl_2	0.00002	0.0002	0.002
2 North/ 6 and 7	PCE/TCE	8	10	20	PCE	1.5×10^{-8}	1.5×10^{-7}	3.7×10^{-6}	0.05	0.1	0.2	PCE	0.00004	0.0004	0.004
					TCE	5.0×10^{-9}	5.0×10^{-8}	3.0×10^{-7}				TCE	0.00004	0.0004	0.004
					DCE	3.0×10^{-9}	2.6×10^{-8}	2.0×10^{-7}				DCE	0.0002	0.002	0.02
					VC	8.0×10^{-11}	8.0×10^{-10}	2.0×10^{-9}				VC	0.002	0.02	0.2
2 South	CCl_4	5	15	25	CCl_4	1.8×10^{-8}	1.8×10^{-7}	3.5×10^{-7}	0.05	0.1	0.2	CCl_4	0.00004	0.0004	0.004
					CCl_3	1.9×10^{-9}	1.9×10^{-8}	3.8×10^{-8}				CCl_3	0.00003	0.0003	0.003
					CCl_2	3.0×10^{-10}	2.8×10^{-9}	2.0×10^{-9}				CCl_2	0.00002	0.0002	0.002
2 South	PCE/TCE	5	15	25	PCE	1.5×10^{-8}	1.5×10^{-7}	3.7×10^{-6}	0.05	0.1	0.2	PCE	0.00003	0.0003	0.003
					TCE	5.0×10^{-9}	5.0×10^{-8}	3.0×10^{-7}				TCE	0.00001	0.0001	0.001
					DCE	3.0×10^{-9}	2.6×10^{-8}	2.0×10^{-7}				DCE	0.00001	0.0001	0.001
					VC	8.0×10^{-11}	8.0×10^{-10}	2.0×10^{-9}				VC	0.001	0.01	0.1
5	PCE/TCE	5	15	25	PCE	1.5×10^{-8}	1.5×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	PCE	0.00003	0.0003	0.003
					TCE	5.0×10^{-9}	5.0×10^{-8}	3.0×10^{-7}				TCE	0.00005	0.0005	0.005
					DCE	3.0×10^{-9}	2.6×10^{-8}	2.0×10^{-7}				DCE	0.0002	0.002	0.02
					VC	8.0×10^{-11}	8.0×10^{-10}	2.0×10^{-9}				VC	0.02	0.2	0.2
9	CCl_4	5	15	30	CCl_4	1.8×10^{-8}	1.8×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	CCl_4	0.0002	0.002	0.02
					CCl_3	1.9×10^{-9}	1.9×10^{-8}	3.0×10^{-6}				CCl_3	0.0001	0.001	0.01
					CCl_2	3.0×10^{-10}	2.8×10^{-9}	2.0×10^{-6}				CCl_2	1E-06	1E-05	0.0001
9	PCE/TCE	5	15	30	PCE	1.5×10^{-8}	1.5×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	PCE	0.001	0.01	0.1
					TCE	5.0×10^{-9}	5.0×10^{-8}	3.0×10^{-6}				TCE	0.0005	0.005	0.05
					DCE	3.0×10^{-9}	2.6×10^{-8}	2.0×10^{-6}				DCE	0.001	0.01	0.1
					VC	8.0×10^{-11}	8.0×10^{-10}	2.0×10^{-6}				VC	0.01	0.1	1

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Table C-1
Modeled Parameter Ranges
(Report Section 6)

PSA No.	Chain Modeled	Dispersivity (m^2/day)			Sorption Coefficient (L/mg)				Porosity			Degradation (day^{-1})			
		Low Values	Mod-erate	High Values	Sorption Analyte	Low Values	Moderate	High Values	Low Values	Mod-erate	High Values	Degradation Analyte	Low Values	Mod-erate	High Values
10	CCl_4	5	15	30	CCl_4	1.8×10^{-8}	1.8×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	CCl_4	0.0002	0.002	0.02
					CCl_3	1.9×10^{-9}	1.9×10^{-8}	3.0×10^{-6}				CCl_3	0.0001	0.001	0.01
					CCl_2	3.0×10^{-10}	2.8×10^{-9}	2.0×10^{-6}				CCl_2	0.0003	0.003	0.03
12	CCl_4	5	15	30	CCl_4	1.8×10^{-8}	1.8×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	CCl_4	0.002	0.02	0.2
					CCl_3	1.9×10^{-9}	1.9×10^{-8}	3.0×10^{-6}				CCl_3	0.001	0.01	0.1
					CCl_2	3.0×10^{-10}	2.8×10^{-9}	2.0×10^{-6}				CCl_2	0.003	0.03	0.3
12	PCE/TCE	5	15	30	PCE	1.5×10^{-8}	1.5×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	PCE	0.0005	0.005	0.05
					TCE	5.0×10^{-9}	5.0×10^{-8}	3.0×10^{-6}				TCE	0.0005	0.005	0.05
					DCE	3.0×10^{-9}	2.6×10^{-8}	2.0×10^{-6}				DCE	0.001	0.01	0.1
					VC	8.0×10^{-11}	8.0×10^{-10}	2.0×10^{-6}				VC	0.001	0.01	0.1
14	CCl_4	2	5	20	CCl_4	1.8×10^{-8}	1.8×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	CCl_4	0.00002	0.0002	0.002
					CCl_3	1.9×10^{-9}	1.9×10^{-8}	3.0×10^{-6}				CCl_3	0.0001	0.001	0.01
					CCl_2	3.0×10^{-10}	2.8×10^{-9}	2.0×10^{-6}				CCl_2	0.0003	0.003	0.03
15	CCl_4	5	15	30	CCl_4	1.8×10^{-8}	1.8×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	CCl_4	0.00005	0.0005	0.005
					CCl_3	1.9×10^{-9}	1.9×10^{-8}	3.0×10^{-6}				CCl_3	0.00005	0.0005	0.005
					CCl_2	3.0×10^{-10}	2.8×10^{-9}	2.0×10^{-6}				CCl_2	0.00005	0.0005	0.005
15	PCE/TCE	5	15	30	PCE	1.5×10^{-8}	1.5×10^{-7}	3.7×10^{-6}	0.03	0.1	0.3	PCE	0.0002	0.002	0.02
					TCE	5.0×10^{-9}	5.0×10^{-8}	3.0×10^{-6}				TCE	0.0001	0.001	0.01
					DCE	3.0×10^{-9}	2.6×10^{-8}	2.0×10^{-6}				DCE	0.0003	0.003	0.03
					VC	8.0×10^{-11}	8.0×10^{-10}	2.0×10^{-6}				VC	0.003	0.03	0.3

Table C-2
Modeled Concentration Ranges at Inferred Sources

PSA	Row	Column	Layer (see definition below)	CCl4 (ppm)	PCE (ppm)	TCE (ppm)
5	43	93	3		150.0	
5	43	92	3		150.0	
5	42	89	3		18.0	11.0
9	69	69	3	0.3	0.2	0.4
9	69	70	3	0.3	0.2	1.7
10	57	25	2		0.5	2.0
10	60	30	2		1.0	
10	61	27	2		0.1	
12	36	41	2	2.0		
12	33	43	2	0.7		
12	31	43	2	0.7		
12	33	43	2		0.2	0.5
12	38	39	2		0.5	0.5
12	35	41	2		0.5	0.5
12	37	24	2		0.3	0.2
12	44	47	2		0.1	3.0
12	36	36	2		1.0	2.0
12	44	34	2		1.5	0.5
14	24	54	3	4.5		
14	24	53	3	4.5		
14	24	52	3	4.5		
14	23	50	4	1.9		
14	23	49	4	1.9		
14	23	48	4	1.9		
15	23	64	3	8.0	0.1	1.0
15	22	64	3	8.0	0.1	1.0
2N	51	88	3	10.0	30.0	4.0
2N	51	89	3	10.0	10.0	2.0
2N	52	87	3	10.0	10.0	2.0
2N	52	88	3	2.0	2.0	
2N	52	89	3	2.0	2.0	
2N	51	88	3	10.0	10.0	4.0
2N	51	89	3	10.0	10.0	2.0
2N	52	87	3	10.0	10.0	2.0
2N	52	88	3	2.0	2.0	
2N	52	89	3	2.0	2.0	
2N	38	109	3	2.0	2.0	
2N	38	110	3	2.0	2.0	
2N	38	111	3	2.0	2.0	
2N	38	112	3	2.0	2.0	
2N	39	104	3	2.0	2.0	
2N	39	105	3	2.0	2.0	
2N	39	106	3	2.0	2.0	
2N	39	107	3	2.0	2.0	
2N	38	113	3	2.0	2.0	
2N	39	112	3	2.0	2.0	
2N	39	113	3	2.0	2.0	
2N	40	108	3	2.0	2.0	
2N	40	109	3	2.0	2.0	
2N	40	110	3	2.0	2.0	
2N	40	112	3	2.0	2.0	
2N	40	113	3	2.0	2.0	
2N	40	112	3	2.0	2.0	
2N	40	113	3	2.0	2.0	

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Table C-2
Modeled Concentration Ranges at Inferred Sources

PSA	Row	Column	Layer (see definition below)	CCl4 (ppm)	PCE (ppm)	TCE (ppm)
2S	50	87	3	10.0	20.0	6.0
2S	51	83	3	10.0	1.0	1.0
2S	51	85	3	40.0	2.0	0.2
2S	51	88	3	4.0	5.0	2.0
2S	51	89	3	40.0	10.0	2.0
2S	55	88	3		0.2	
2S	58	88	3	1.0	4.0	40.0
2S	59	87	3	2.0	4.0	40.0

2: Unconsolidated Material
3: Upper Weathered Bedrock
4: Lower Weathered Bedrock

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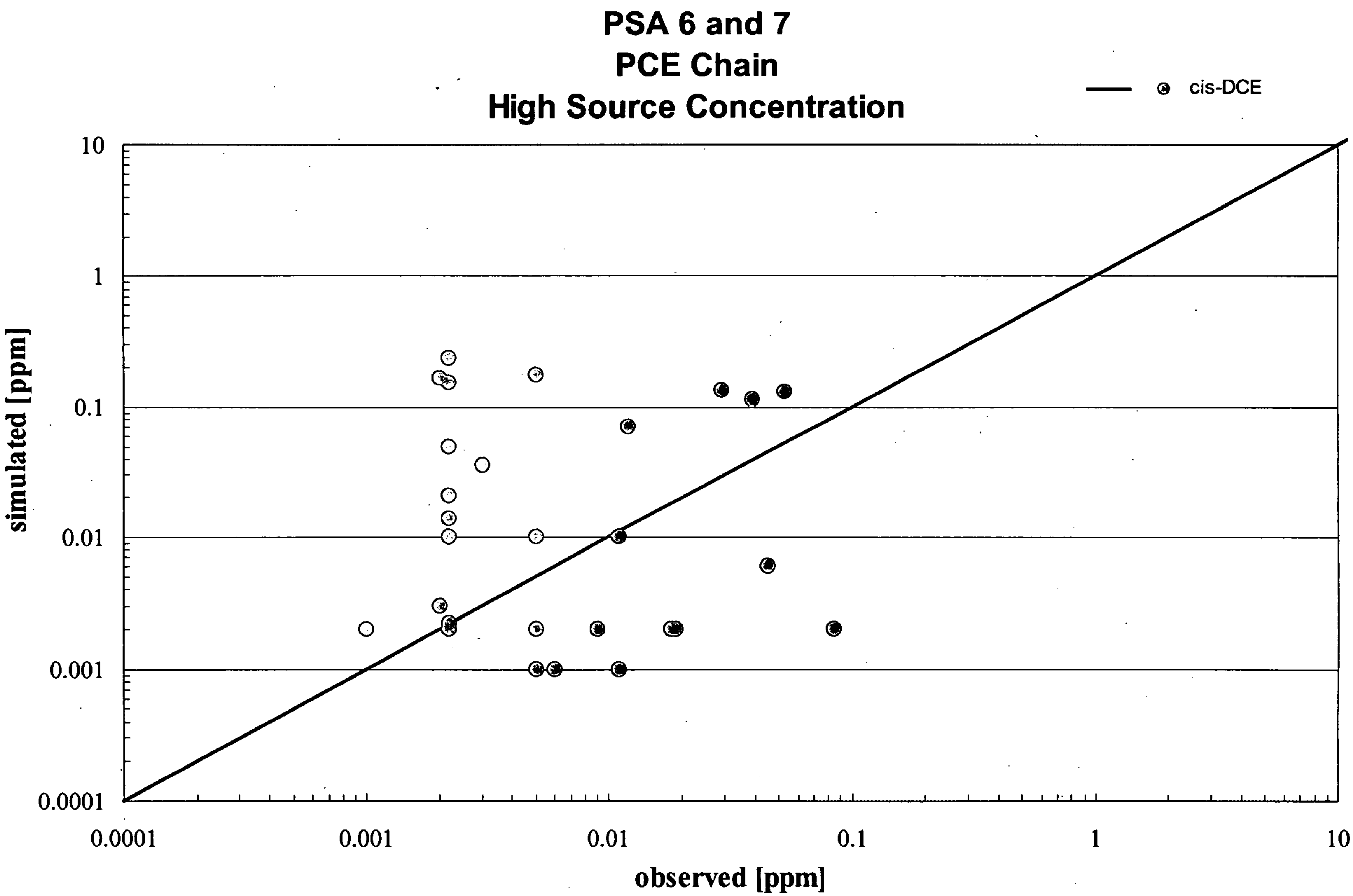

Figure D.1. PSA 6 and 7 - High PCE Daughter Products.

247

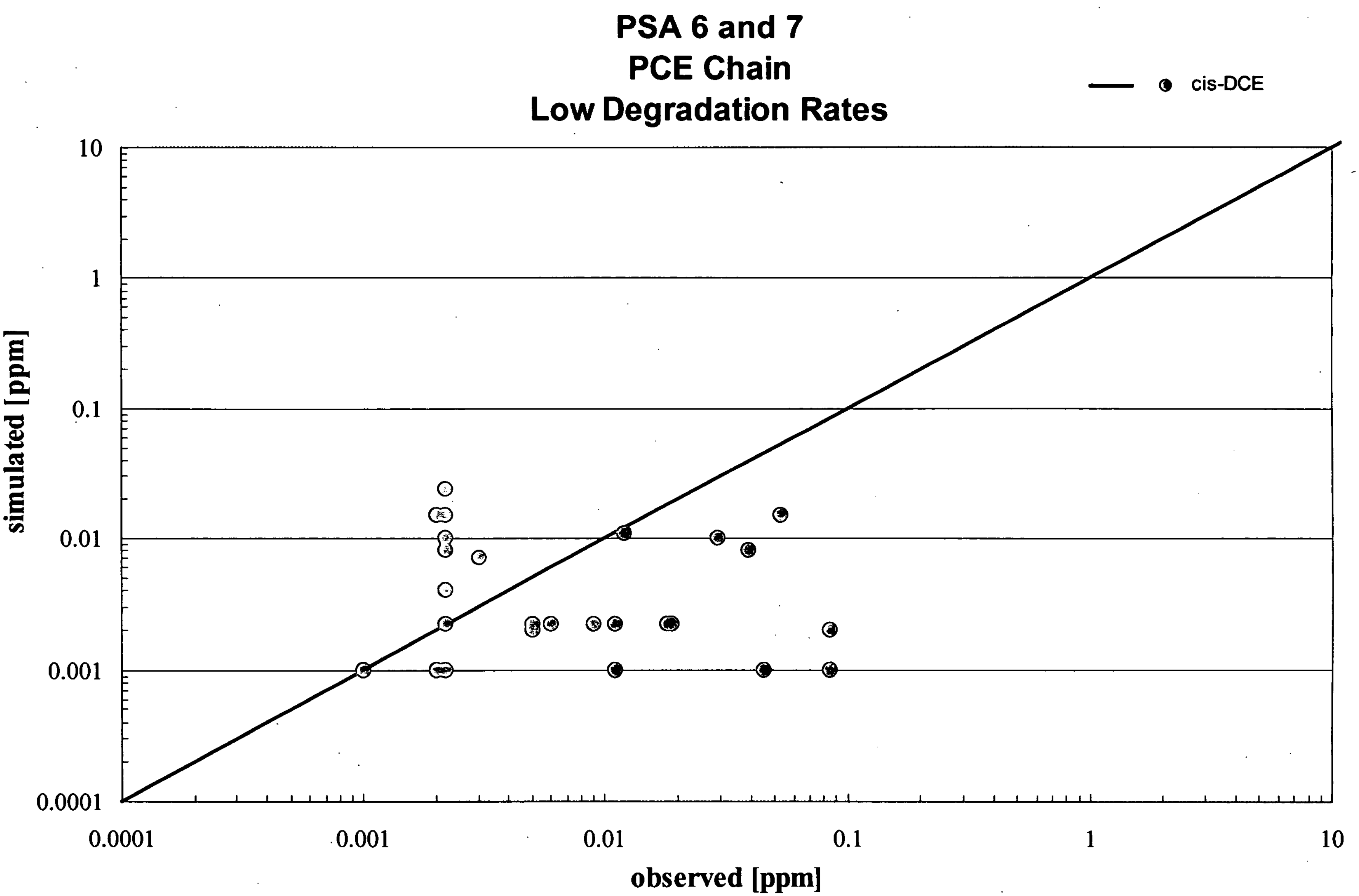

Figure D.2. PSA 6 and 7 - Low PCE Daughter Products.

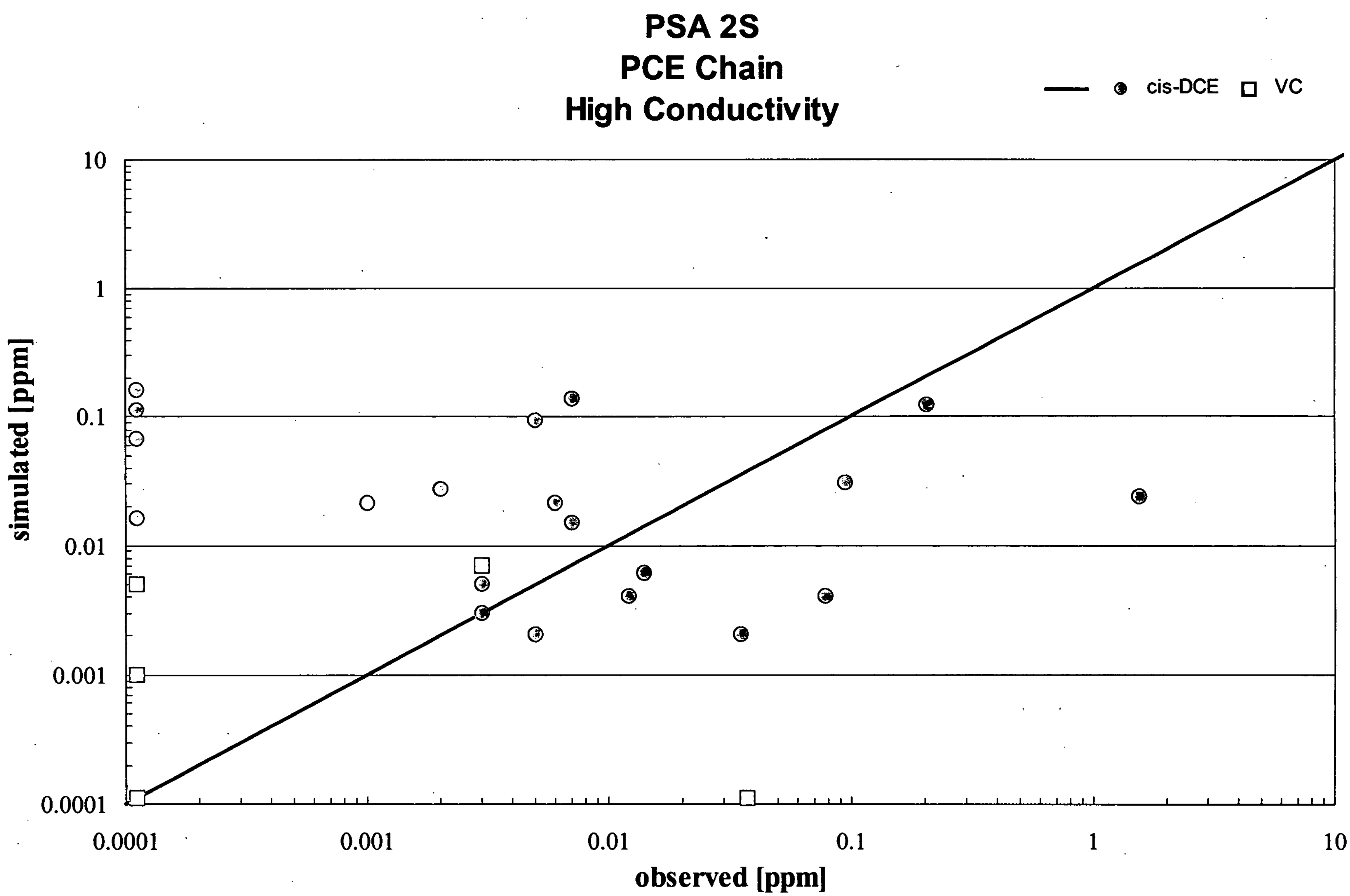

Figure D.3. PSA 2S - High PCE Daughter Products.

244

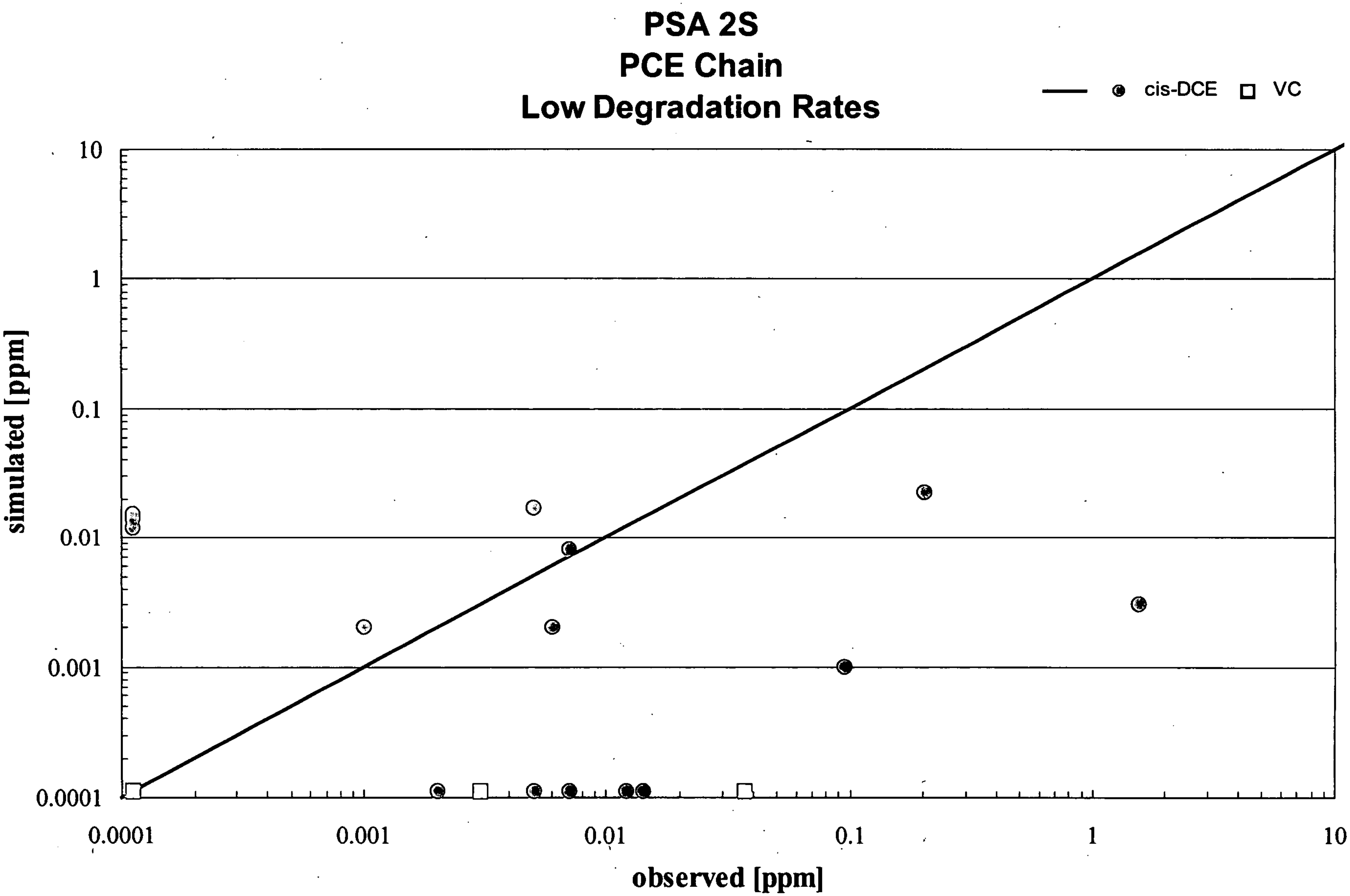

Figure D.4. PSA 2S - Low PCE Daughter Products.

250

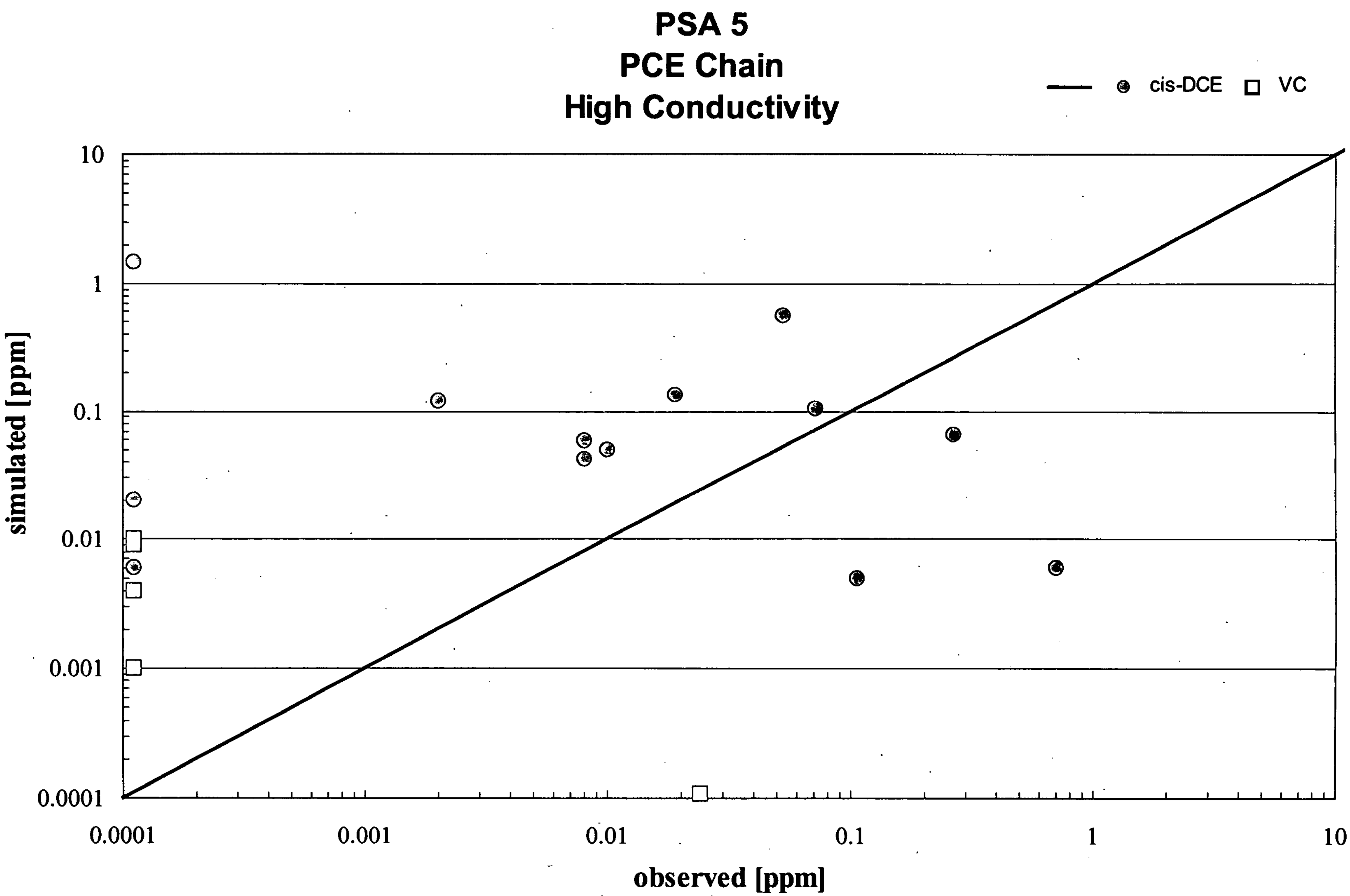

Figure D.5. PSA 5 - High PCE Daughter Products.

252

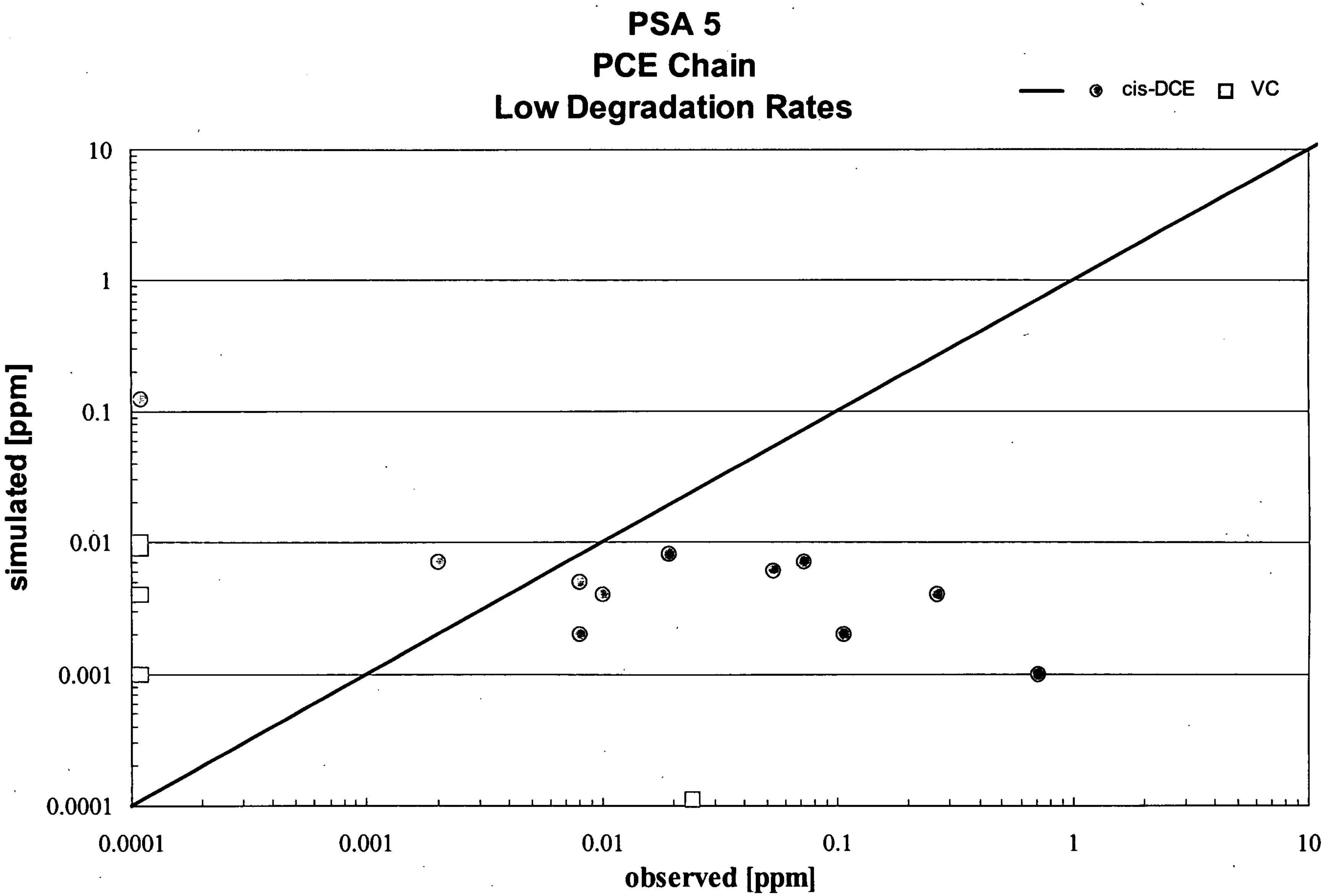

Figure D.6. PSA 5 - Low PCE Daughter Products.

252

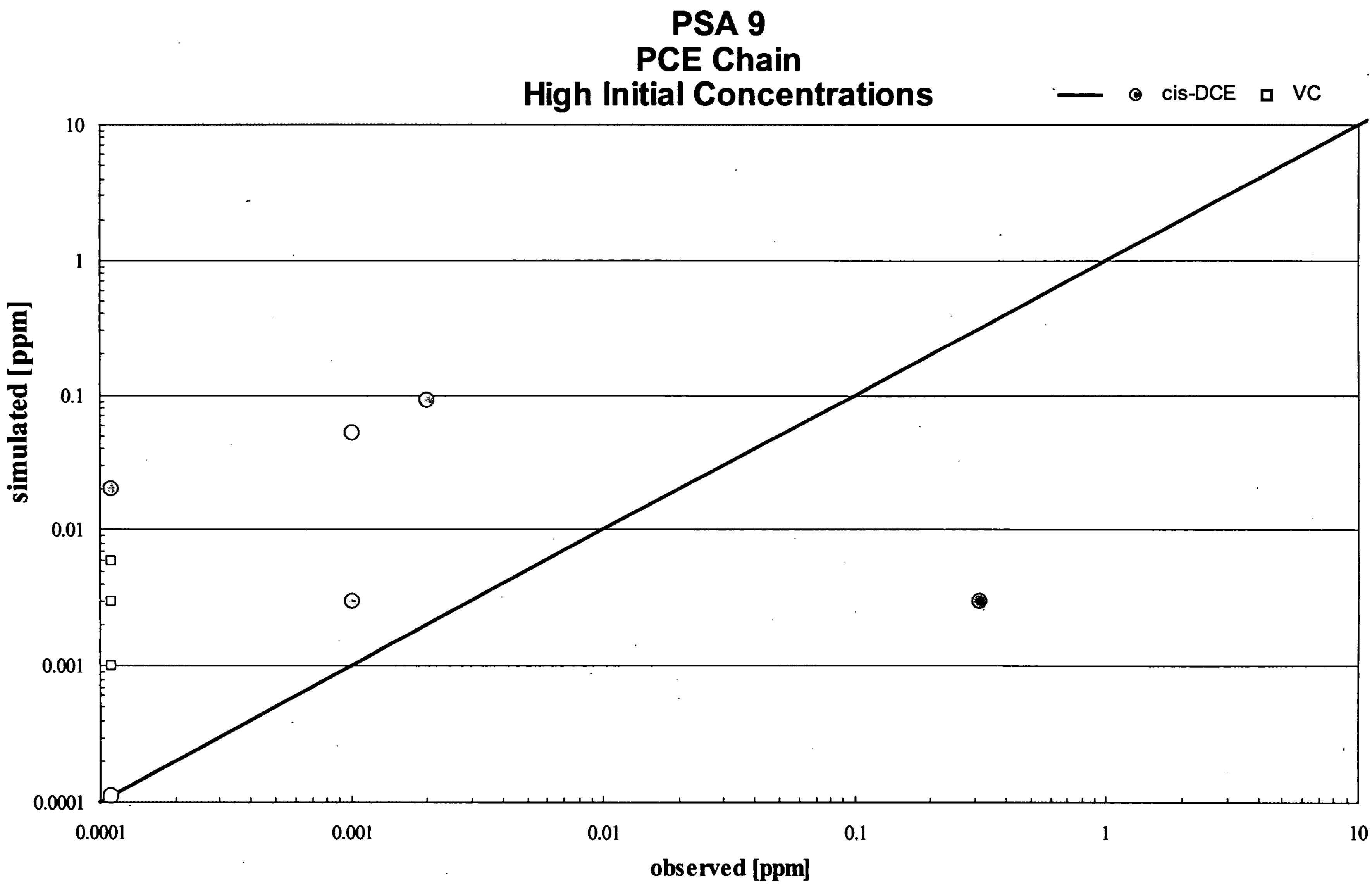

Figure D.7. PSA 9 - High PCE Daughter Products.

253

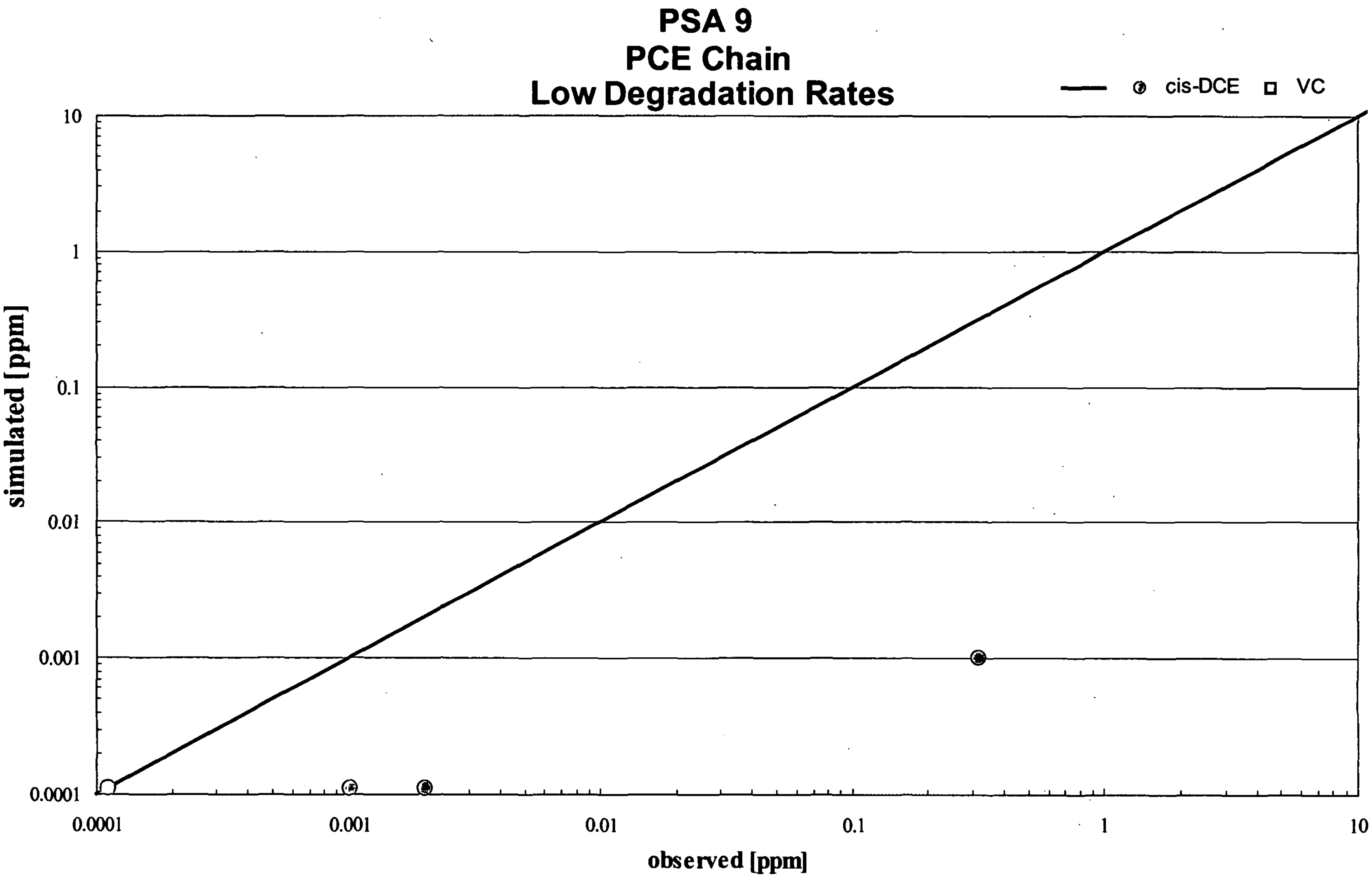

Figure D.8. PSA 9 - Low PCE Daughter Products.

254

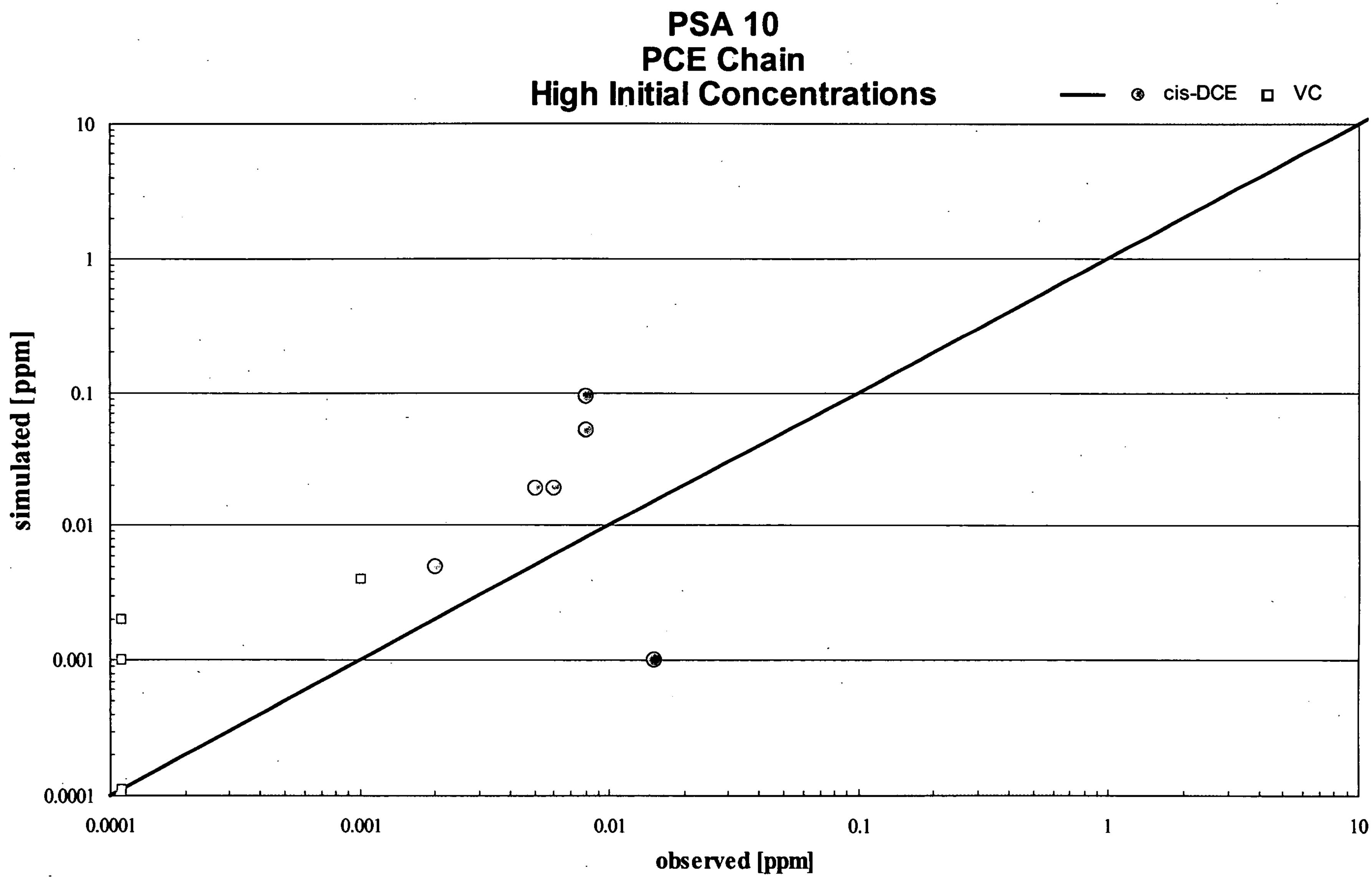

Figure D.9. PSA 10 - High PCE Daughter Products.

255

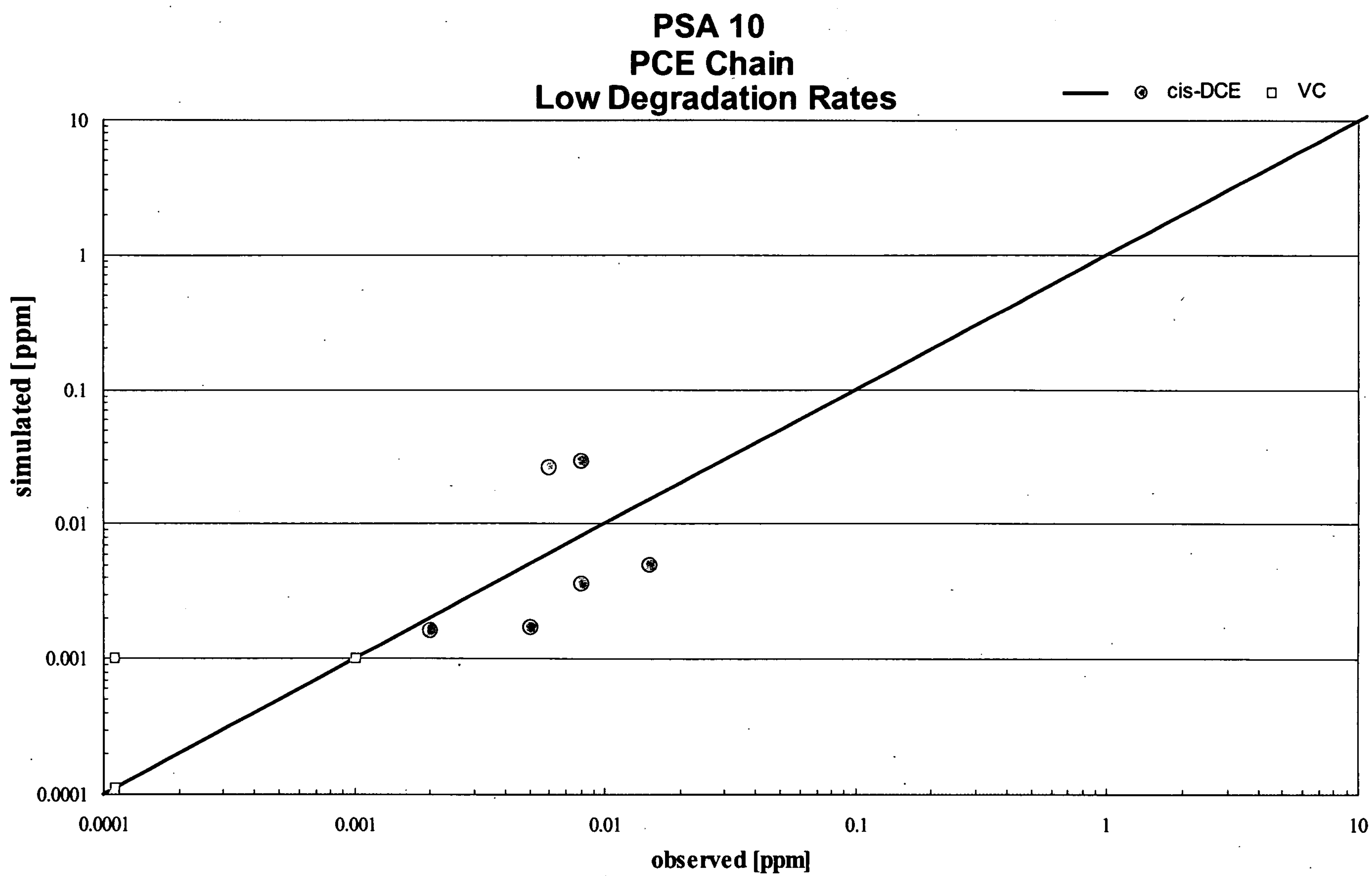

Figure D.10. PSA 10 - Low PCE Daughter Products.

256

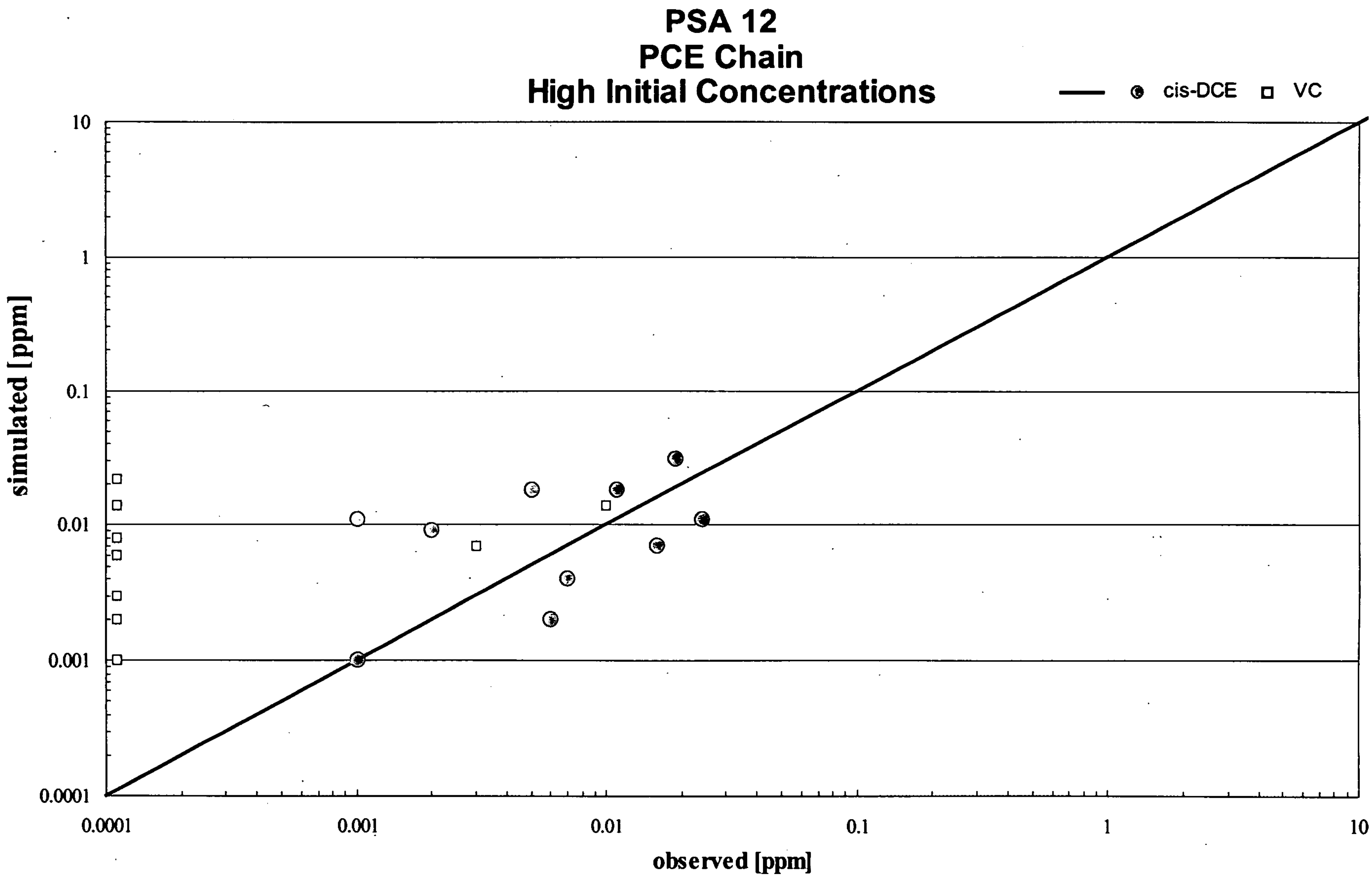

Figure D.11. PSA 12 - High PCE Daughter Products.

257

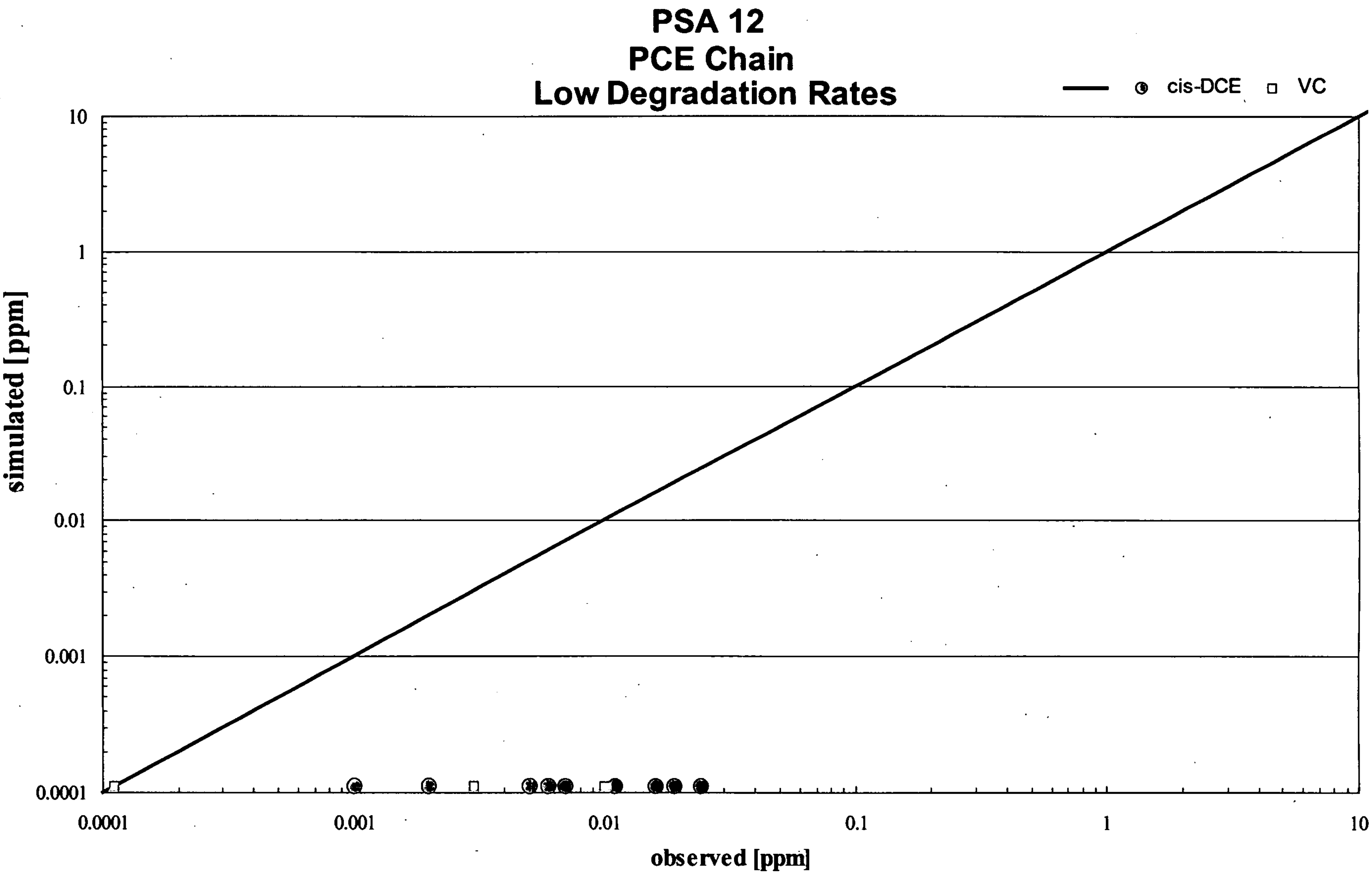

Figure D.12. PSA 12 - Low PCE Daughter Products.

258

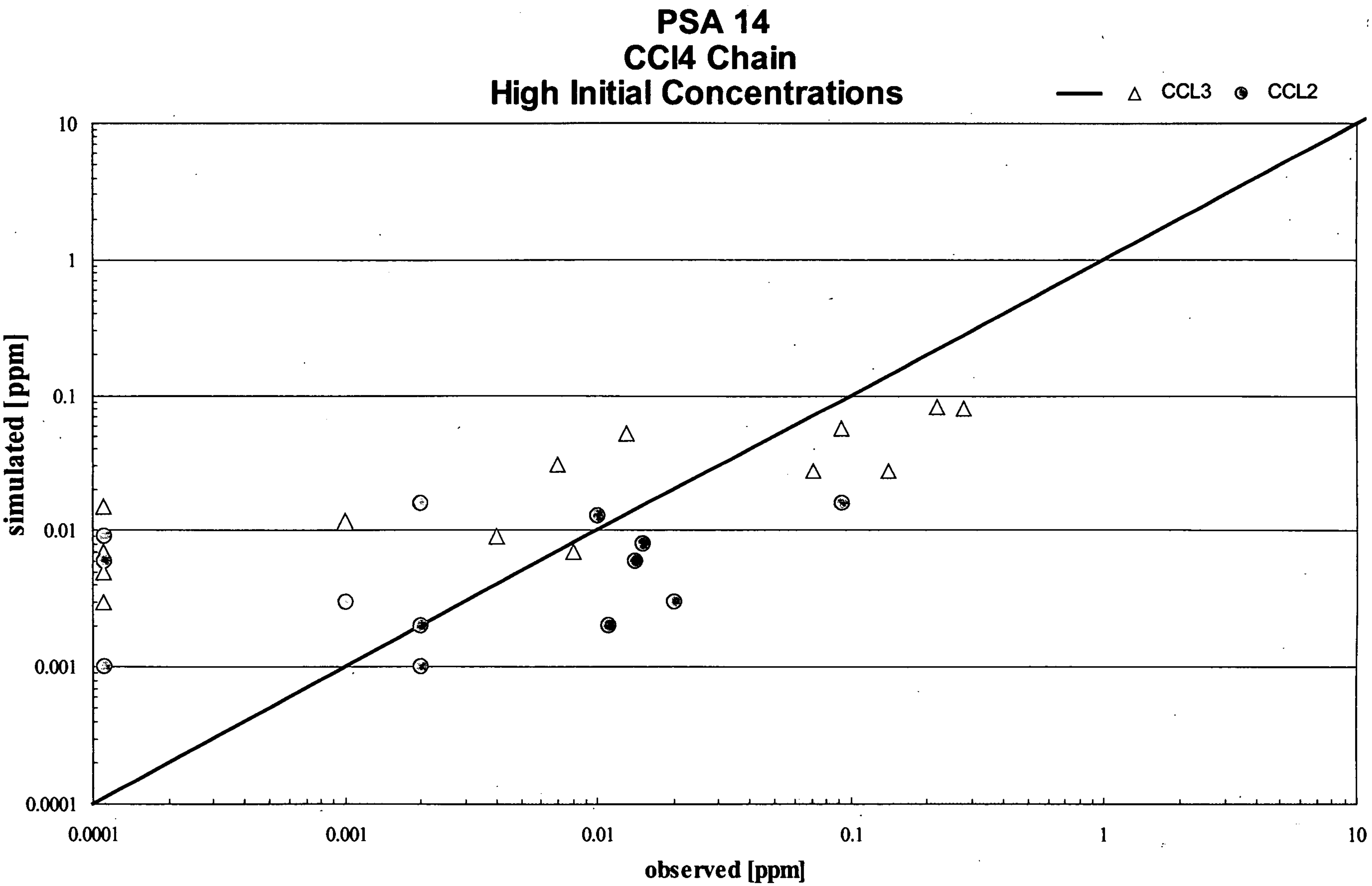

Figure D.13. PSA 14 - High CCl_4 Daughter Products.

259

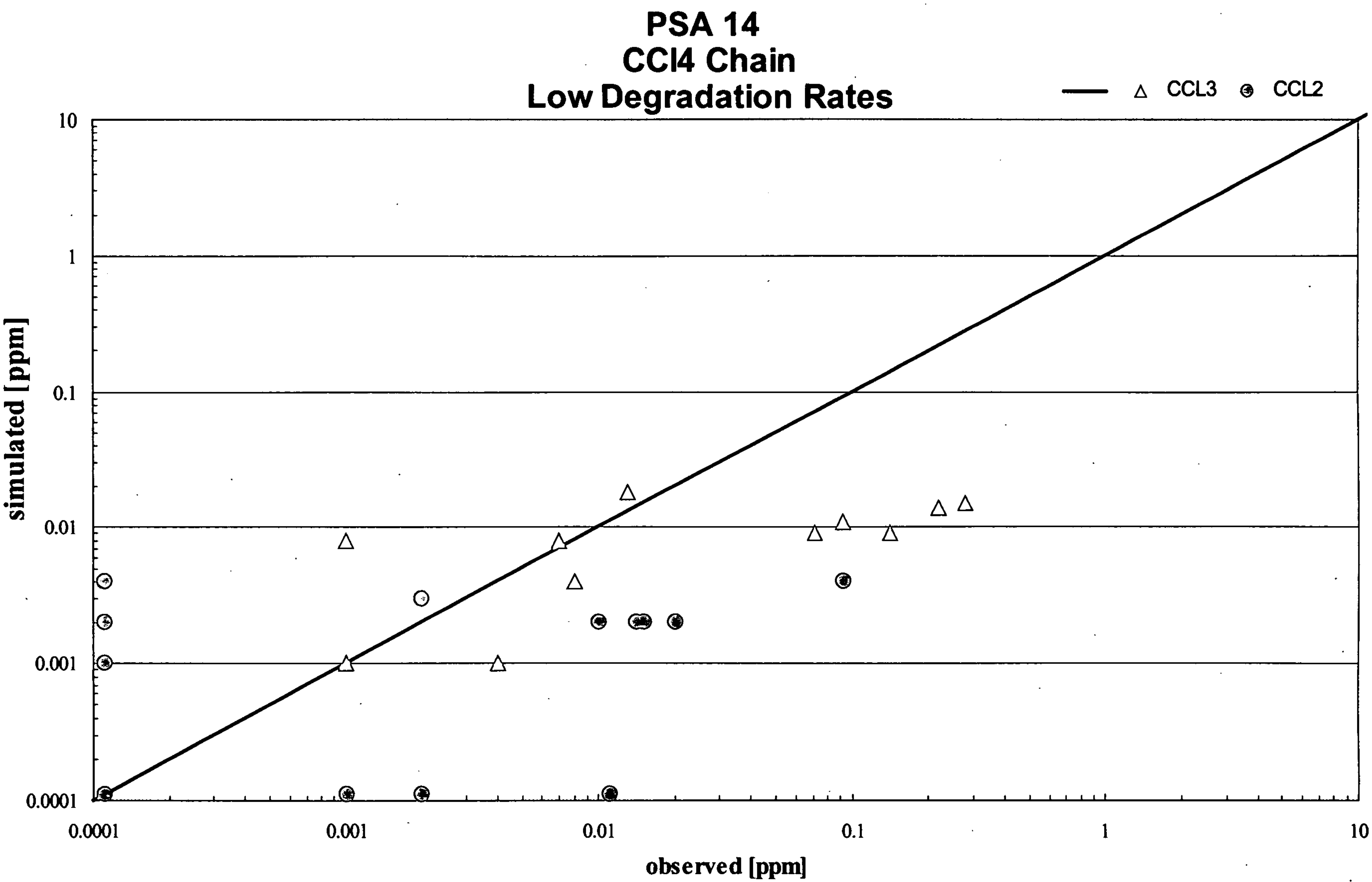

Figure D.14. PSA 14 - Low CCl_4 Daughter Products.

260

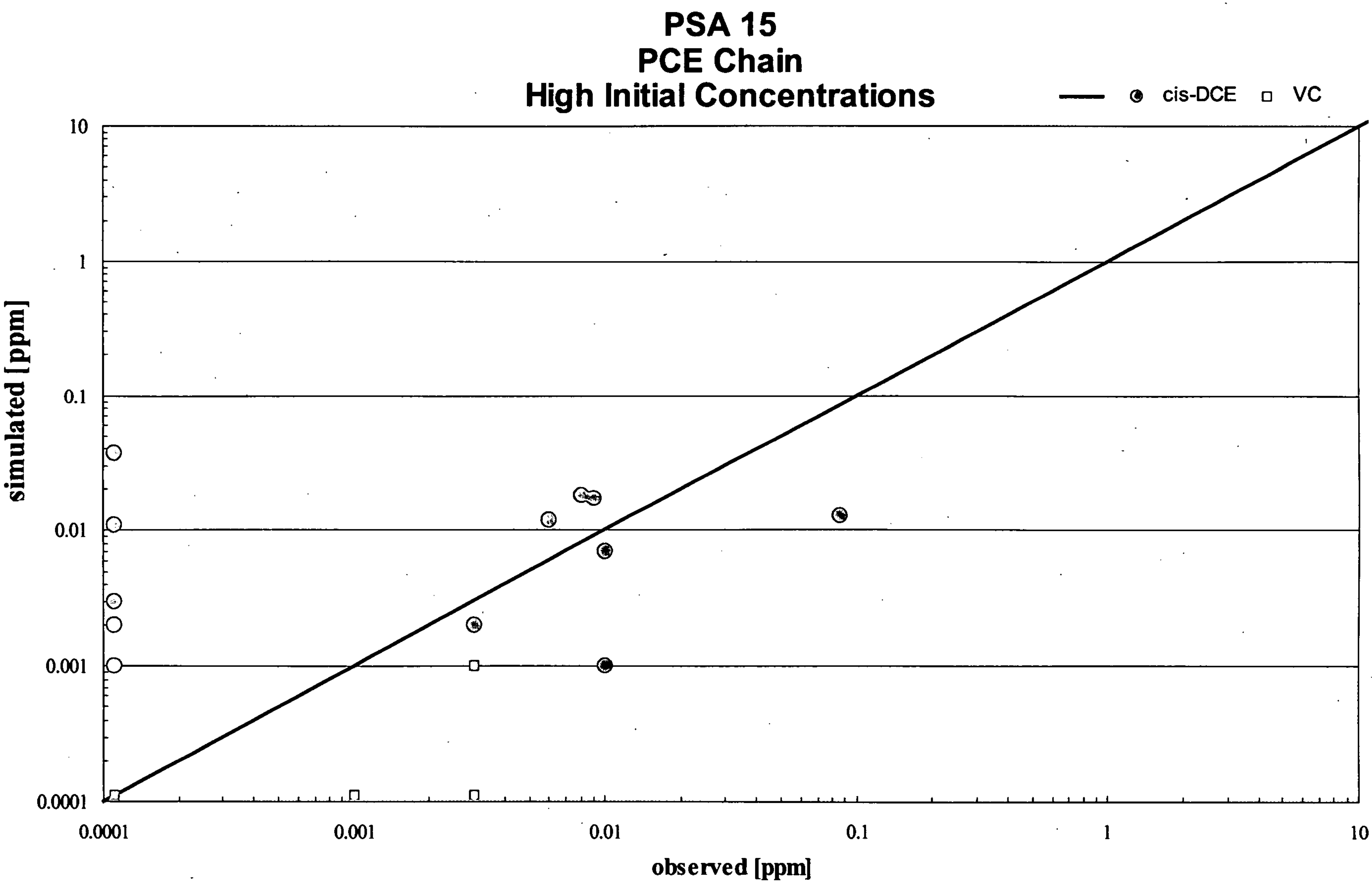

Figure D.15. PSA 15 - High PCE Daughter Products.

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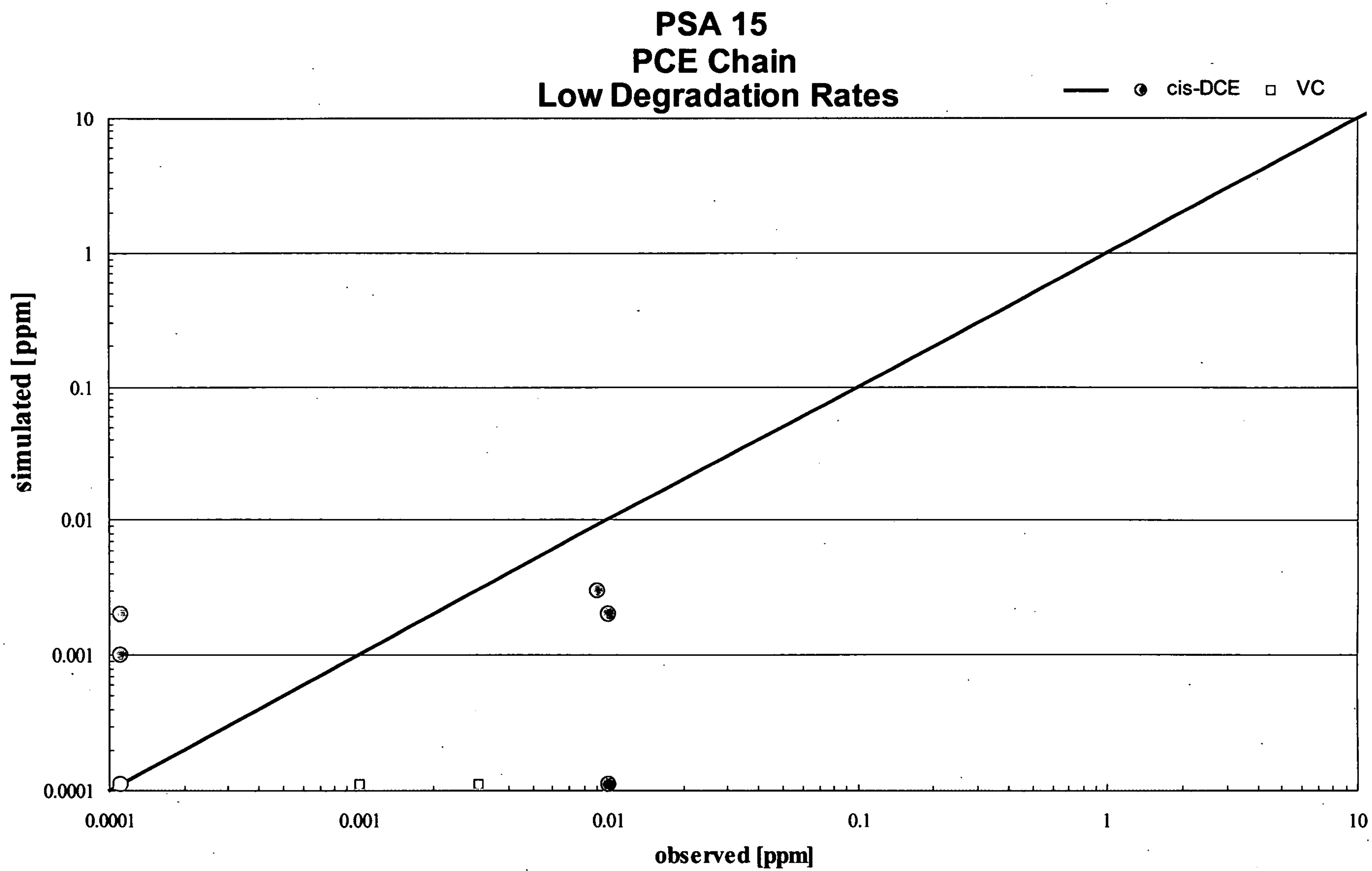
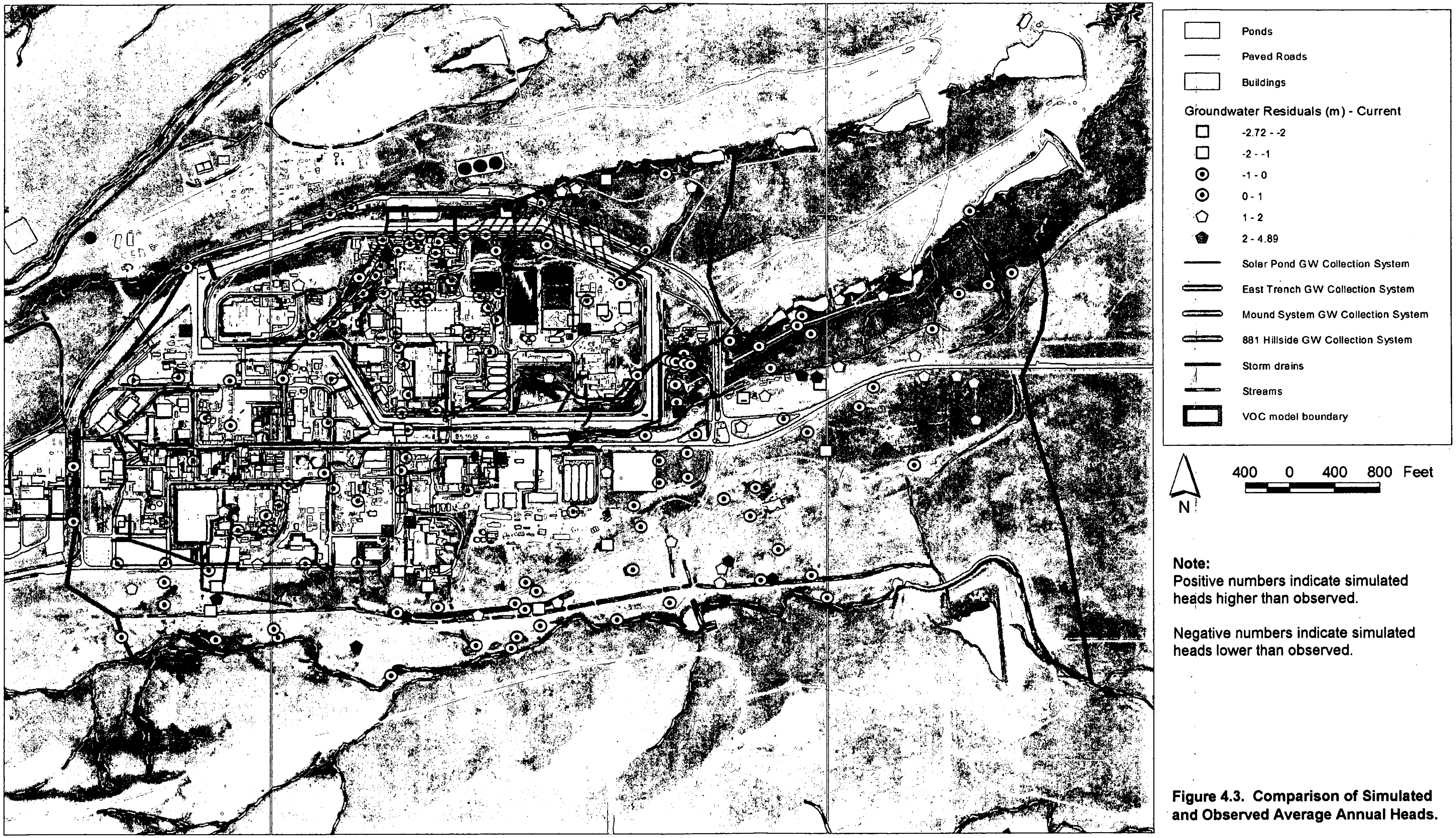


Figure D.16. PSA 15 - Low PCE Daughter Products.



Note:
Positive numbers indicate simulated heads higher than observed.

Negative numbers indicate simulated heads lower than observed.

Figure 4.3. Comparison of Simulated and Observed Average Annual Heads.

71

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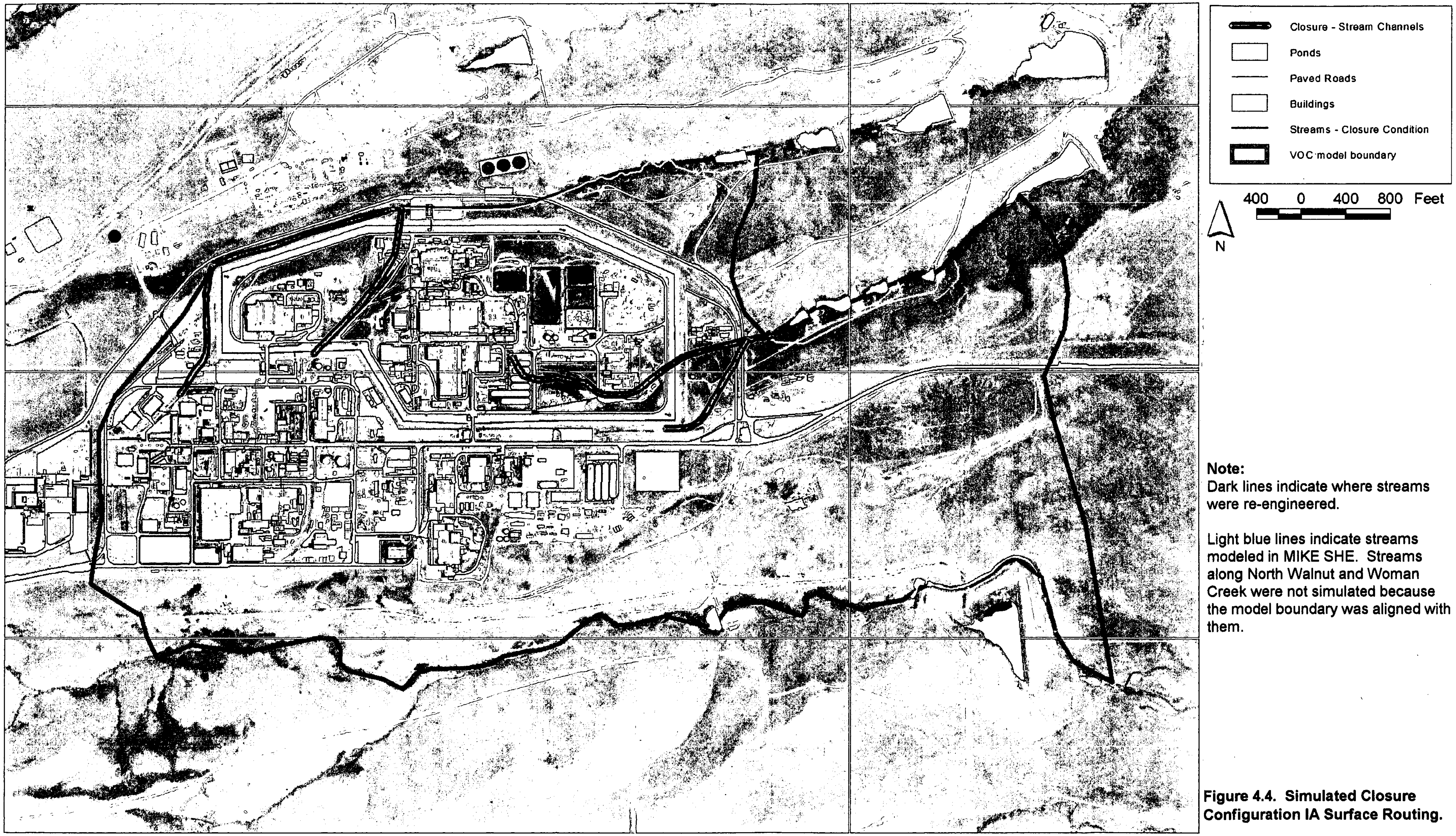

Note:
Dark lines indicate where streams were re-engineered.

Light blue lines indicate streams modeled in MIKE SHE. Streams along North Walnut and Woman Creek were not simulated because the model boundary was aligned with them.

Figure 4.4. Simulated Closure Configuration IA Surface Routing.

74

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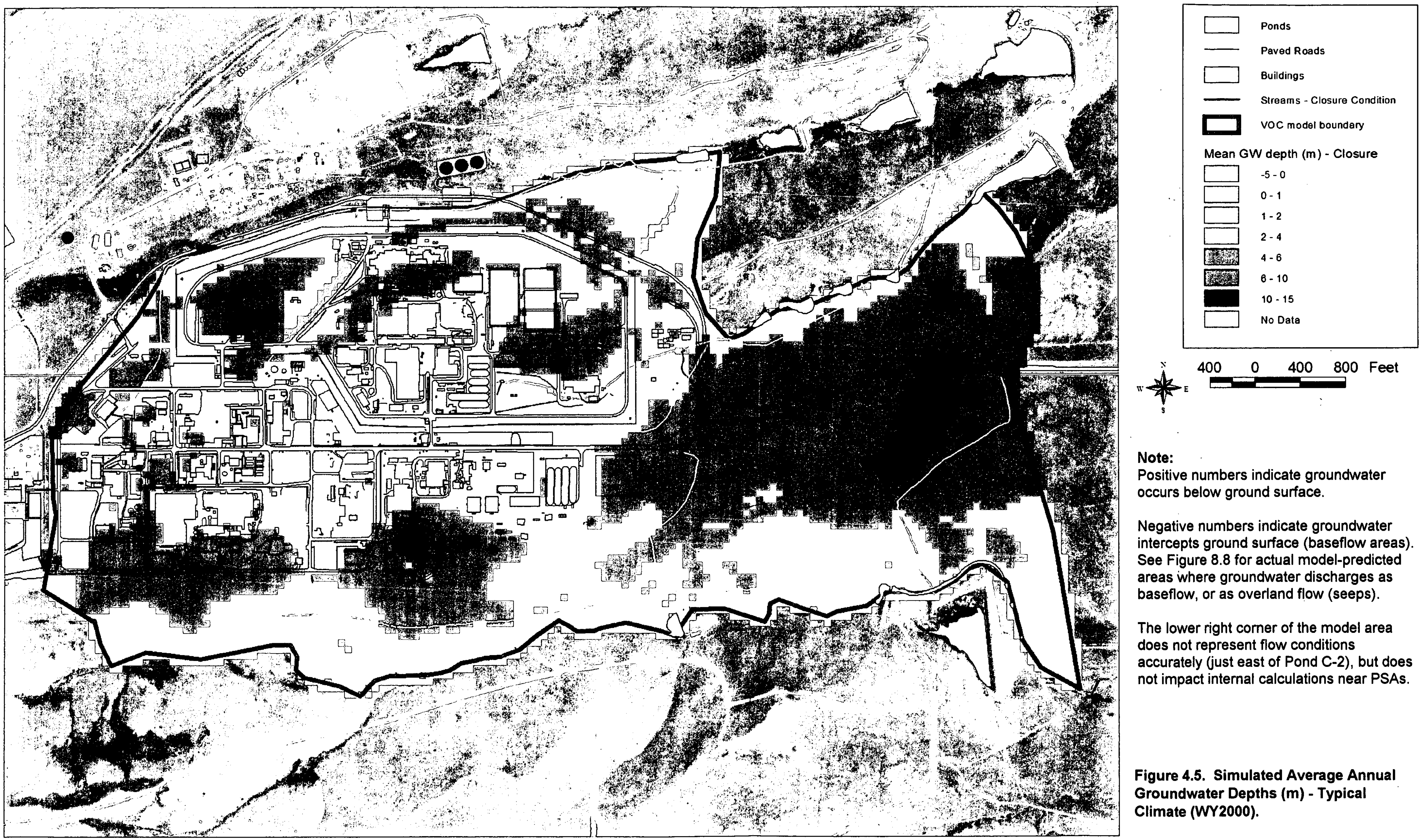


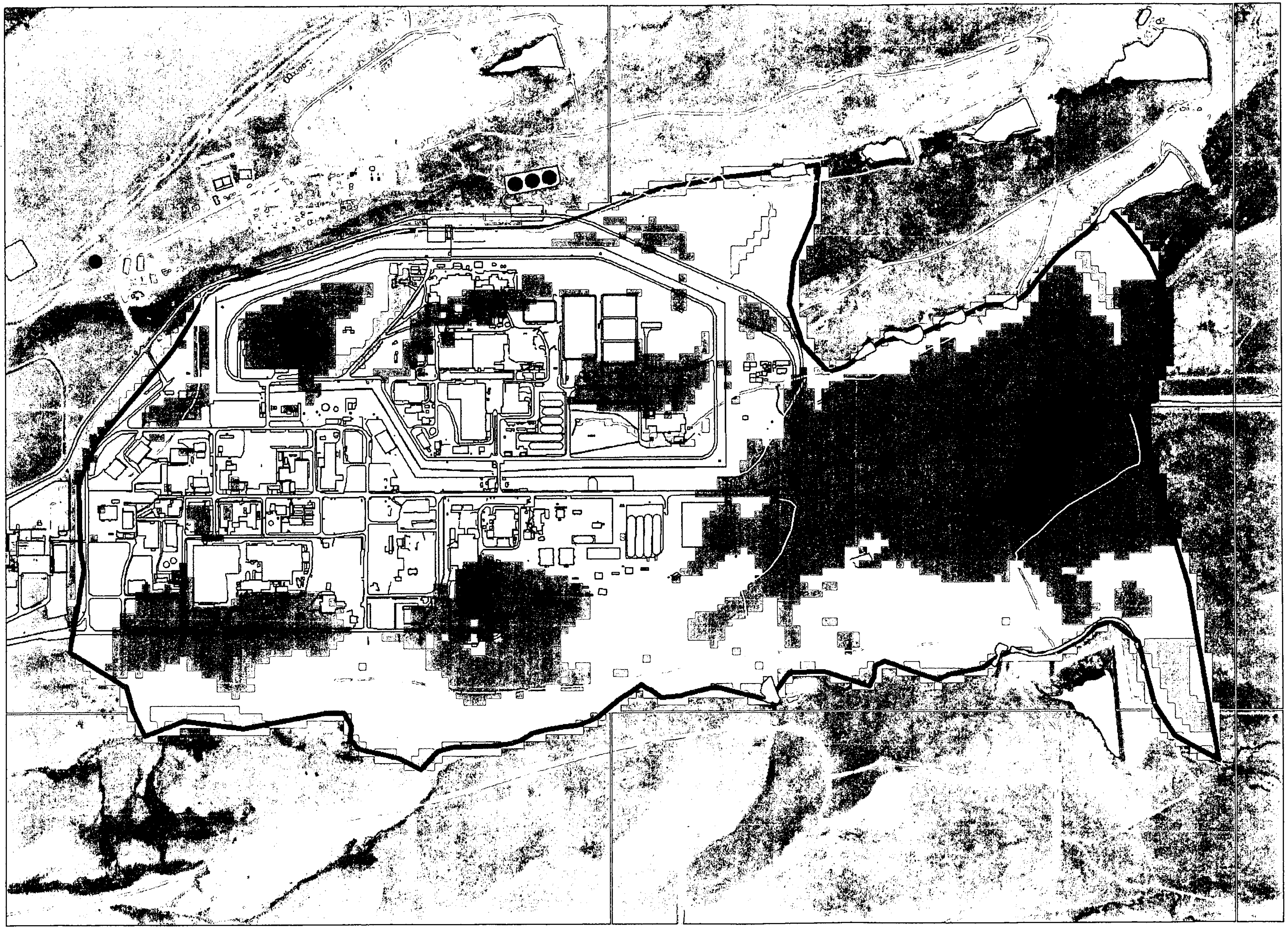
Note:
Positive numbers indicate groundwater occurs below ground surface.

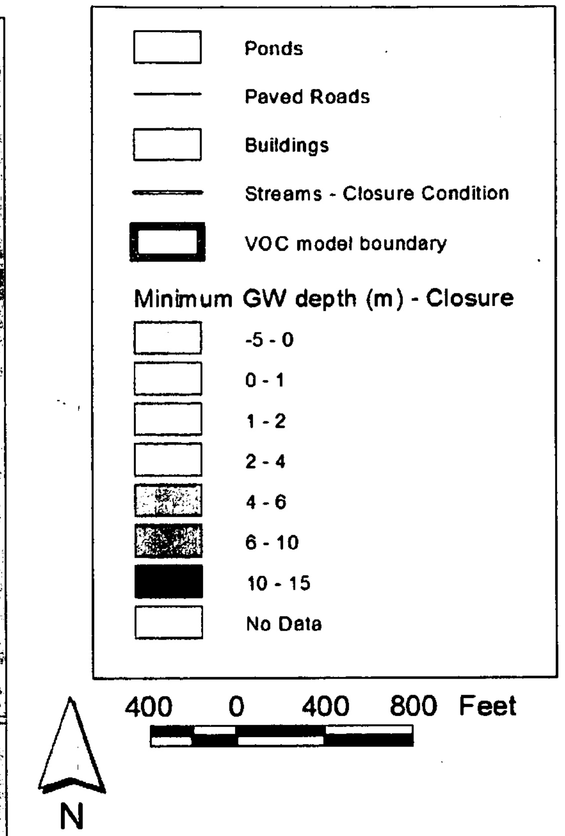
Negative numbers indicate groundwater intercepts ground surface (baseflow areas). See Figure 8.8 for actual model-predicted areas where groundwater discharges as baseflow, or as overland flow (seeps).

The lower right corner of the model area does not represent flow conditions accurately (just east of Pond C-2), but does not impact internal calculations near PSAs.

Figure 4.5. Simulated Average Annual Groundwater Depths (m) - Typical Climate (WY2000).

75





Note:
Positive numbers indicate groundwater occurs below ground surface.

Negative numbers indicate groundwater intercepts ground surface (baseflow areas). See Figure 8.8 for actual model-predicted areas where groundwater discharges as baseflow, or as overland flow (seeps).

The lower right corner of the model area does not represent flow conditions accurately (just east of Pond C-2), but does not impact internal calculations near PSAs.

Figure 4.6. Simulated Minimum Annual Groundwater Depths (m) - Typical Climate (WY2000).

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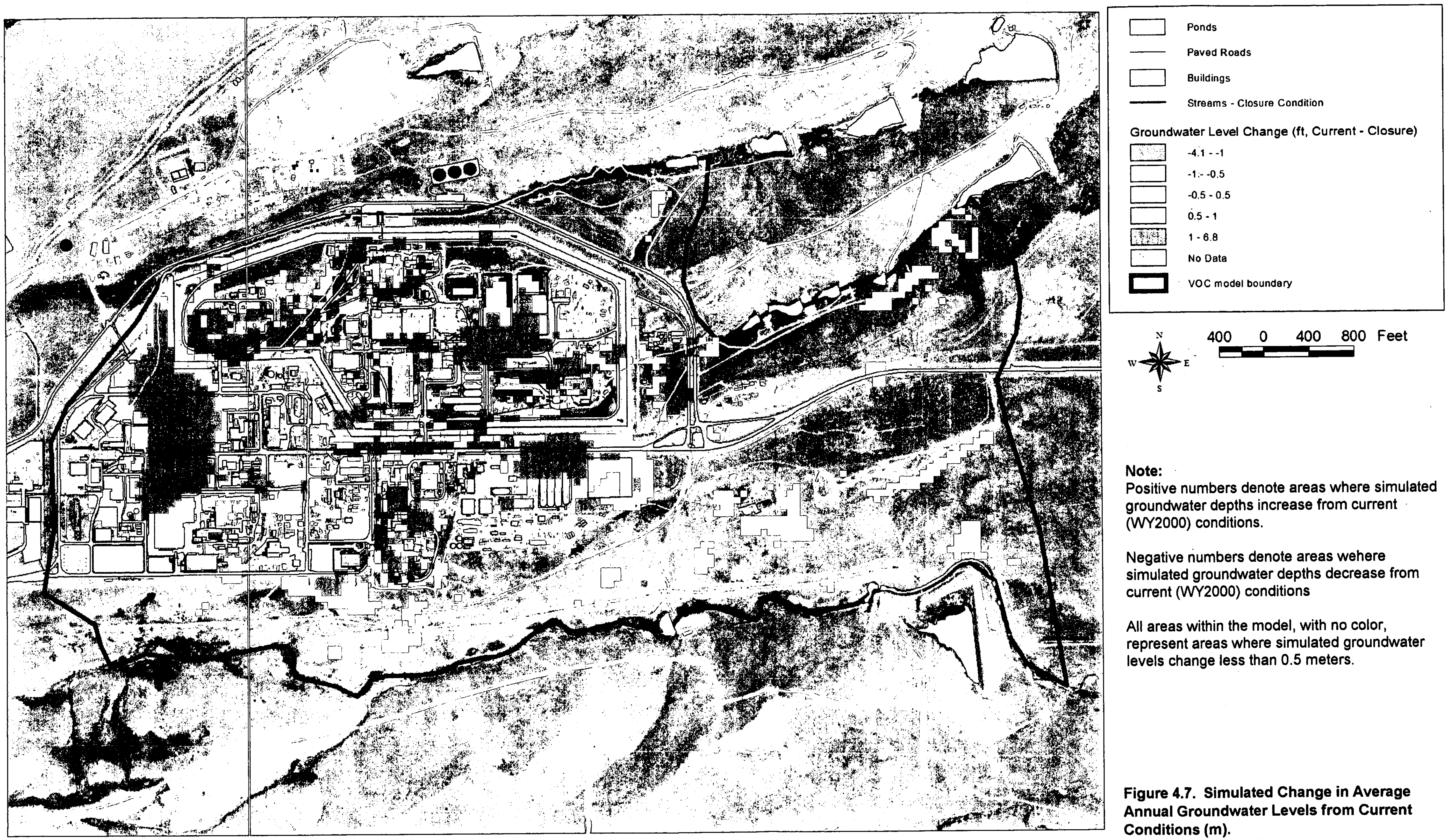

Note:
Positive numbers denote areas where simulated groundwater depths increase from current (WY2000) conditions.

Negative numbers denote areas wehere simulated groundwater depths decrease from current (WY2000) conditions

All areas within the model, with no color, represent areas where simulated groundwater levels change less than 0.5 meters.

Figure 4.7. Simulated Change in Average Annual Groundwater Levels from Current Conditions (m).

78

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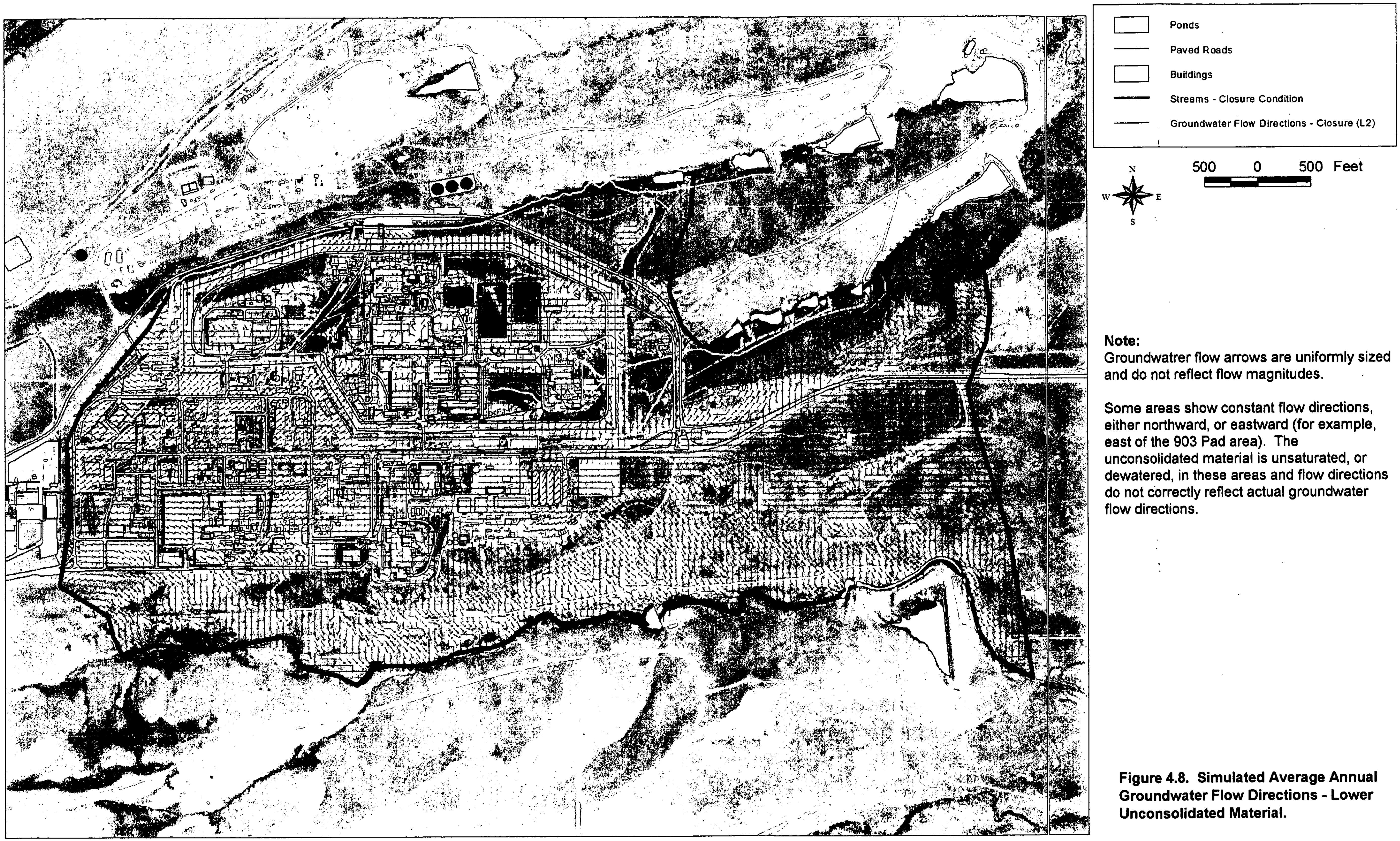

Note:
Groundwatrer flow arrows are uniformly sized and do not reflect flow magnitudes.

Some areas show constant flow directions, either northward, or eastward (for example, east of the 903 Pad area). The unconsolidated material is unsaturated, or dewatered, in these areas and flow directions do not correctly reflect actual groundwater flow directions.

Figure 4.8. Simulated Average Annual Groundwater Flow Directions - Lower Unconsolidated Material.

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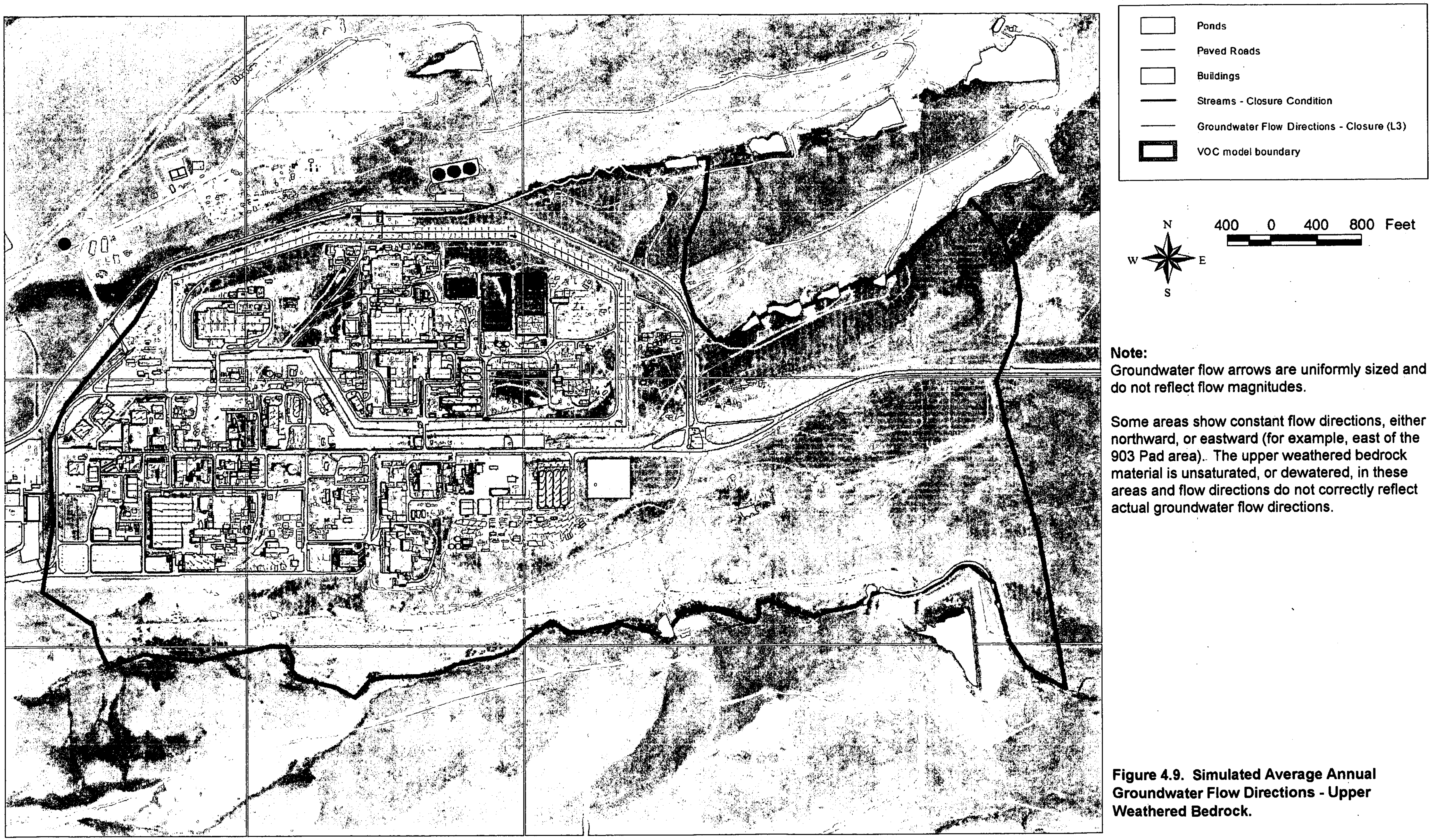

Note:
Groundwater flow arrows are uniformly sized and do not reflect flow magnitudes.

Some areas show constant flow directions, either northward, or eastward (for example, east of the 903 Pad area).. The upper weathered bedrock material is unsaturated, or dewatered, in these areas and flow directions do not correctly reflect actual groundwater flow directions.

Figure 4.9. Simulated Average Annual Groundwater Flow Directions - Upper Weathered Bedrock.

80

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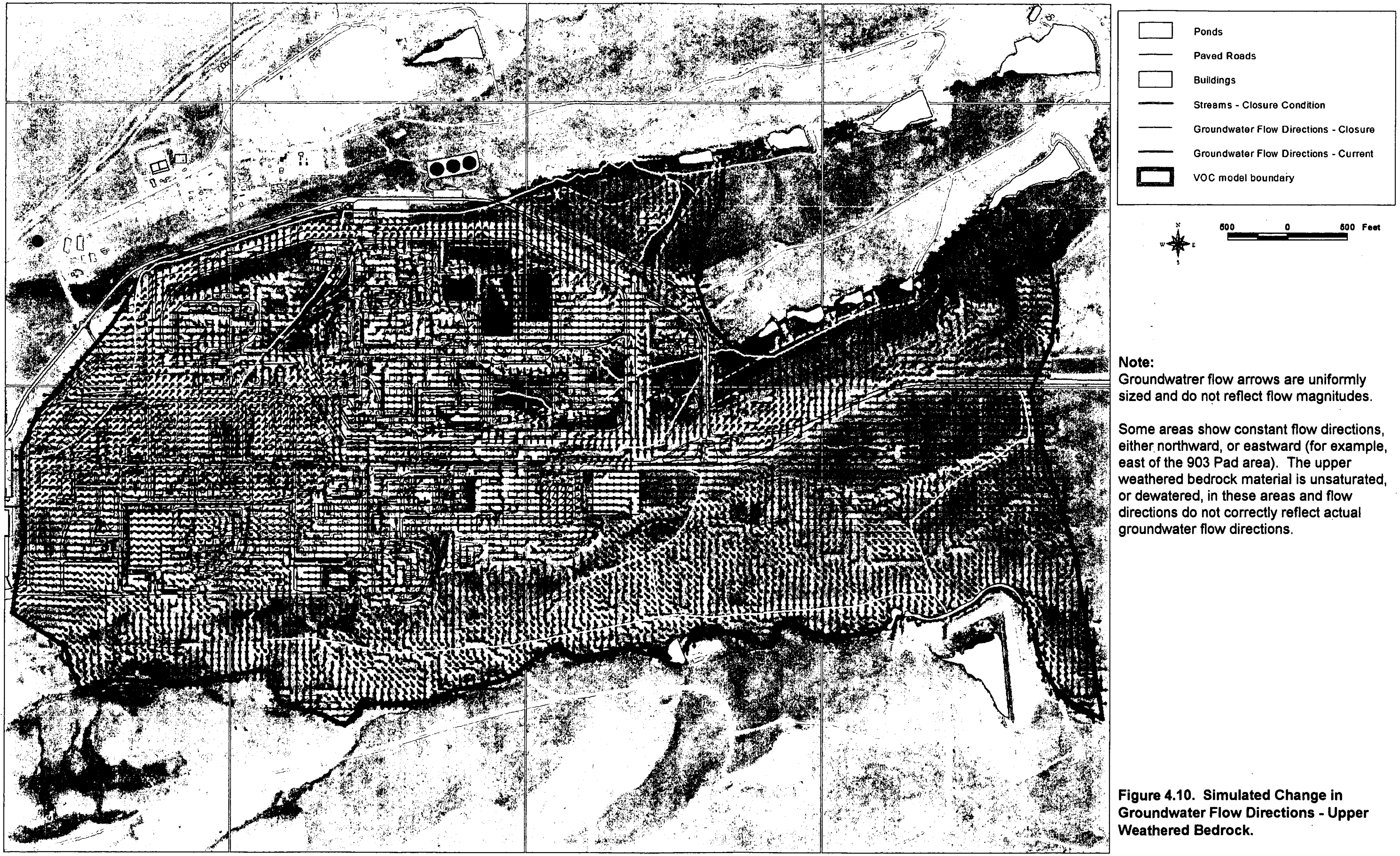

Note:
Groundwatrer flow arrows are uniformly sized and do not reflect flow magnitudes.

Some areas show constant flow directions, either northward, or eastward (for example, east of the 903 Pad area). The upper weathered bedrock material is unsaturated, or dewatered, in these areas and flow directions do not correctly reflect actual groundwater flow directions.

Figure 4.10. Simulated Change in Groundwater Flow Directions - Upper Weathered Bedrock.

81

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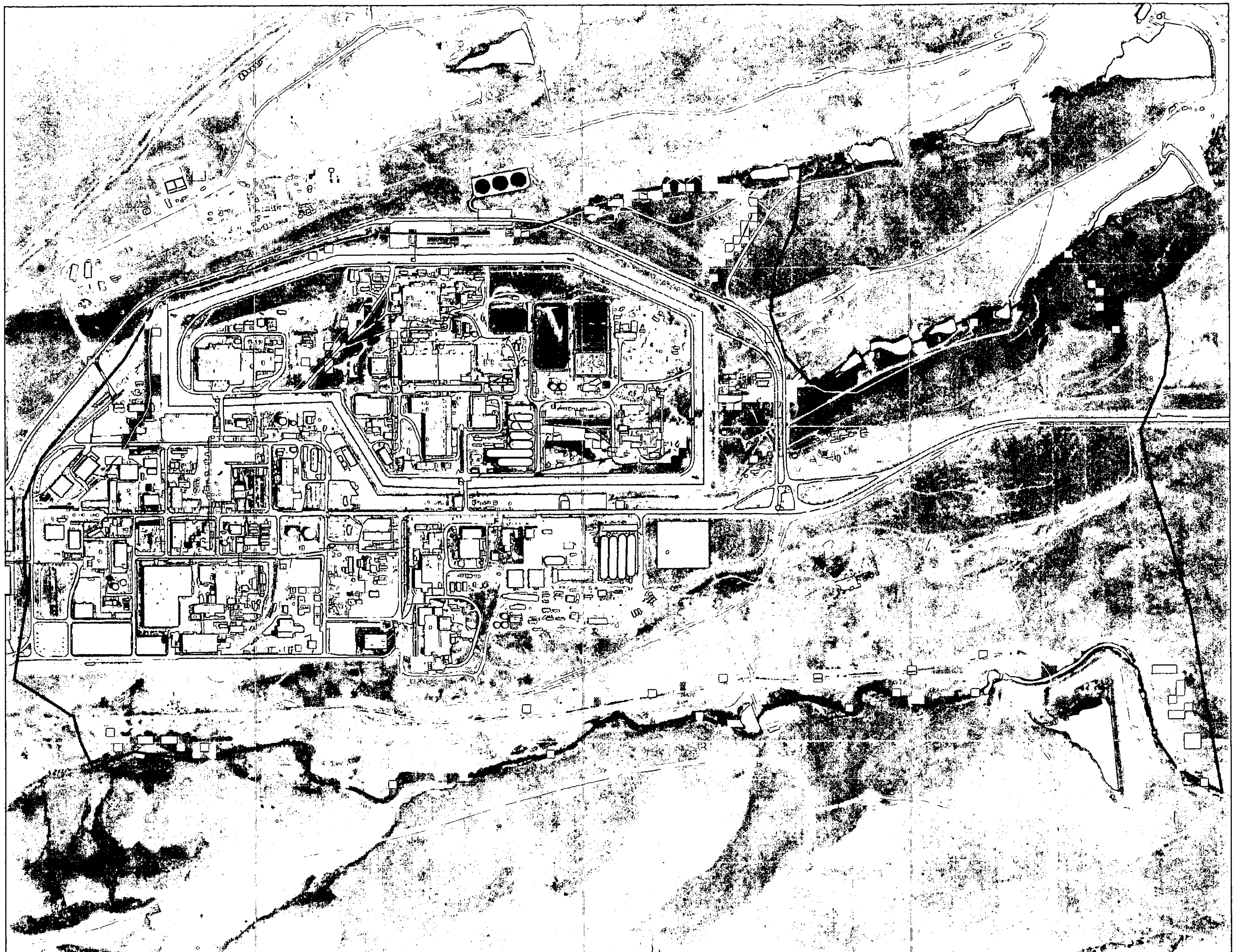


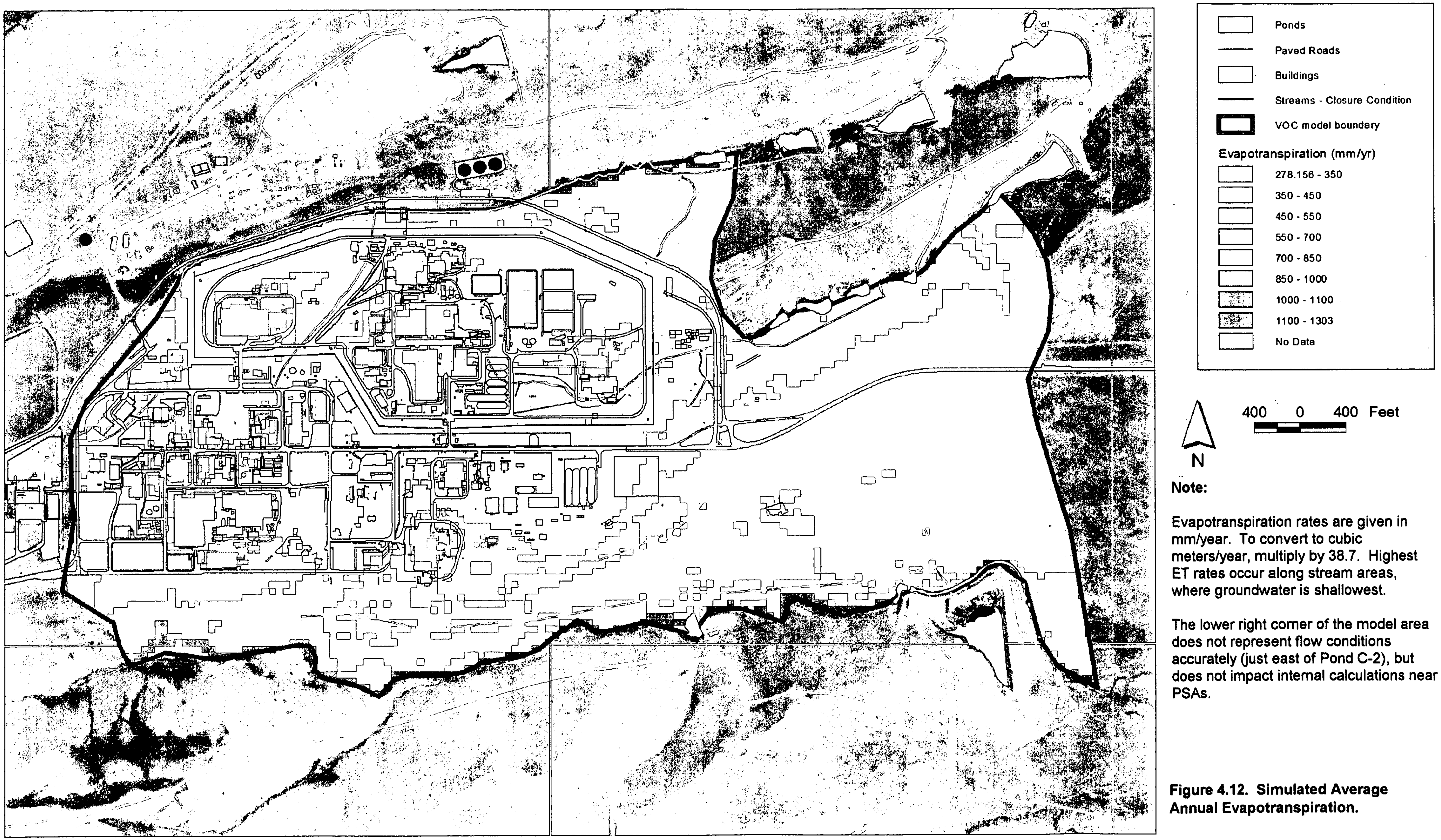
Note:
Positive numbers indicate areas where groundwater discharges to ground surface.

Negative numbers indicate areas where surface water recharges groundwater.

Discharge rates are in cubic meters per year. Rates do not reflect variability of discharge (or recharge) during the year.

North Walnut Creek and Woman Creek coincide with the integrated flow model boundary. As a result, discharge rates at the streams are not accurately calculated as streams in these areas were not simulated explicitly in the model.

Figure 4.11. Simulated Annual Groundwater Discharge Areas.



Note:

Evapotranspiration rates are given in mm/year. To convert to cubic meters/year, multiply by 38.7. Highest ET rates occur along stream areas, where groundwater is shallowest.

The lower right corner of the model area does not represent flow conditions accurately (just east of Pond C-2), but does not impact internal calculations near PSAs.

Figure 4.12. Simulated Average Annual Evapotranspiration.

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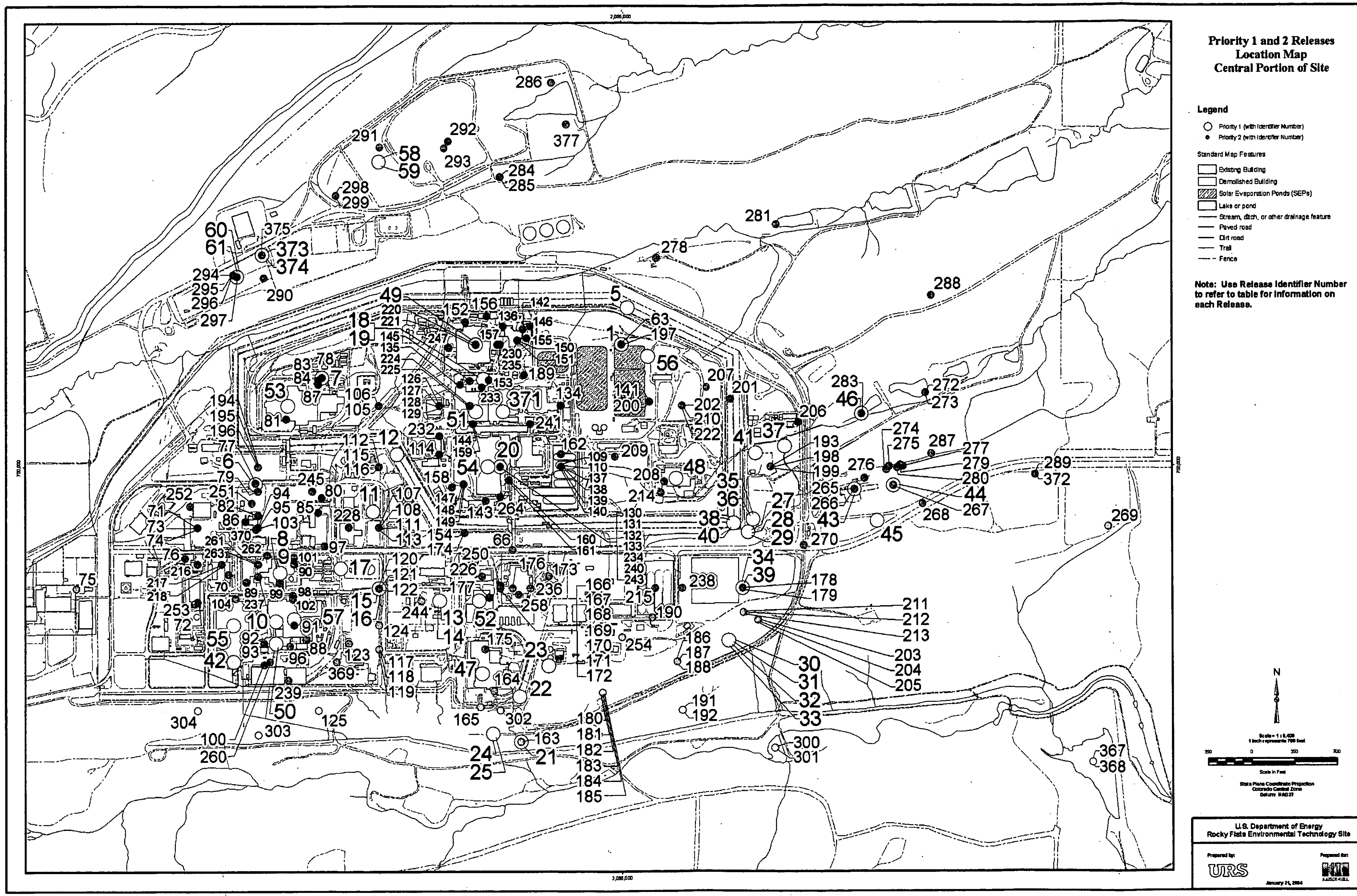
84



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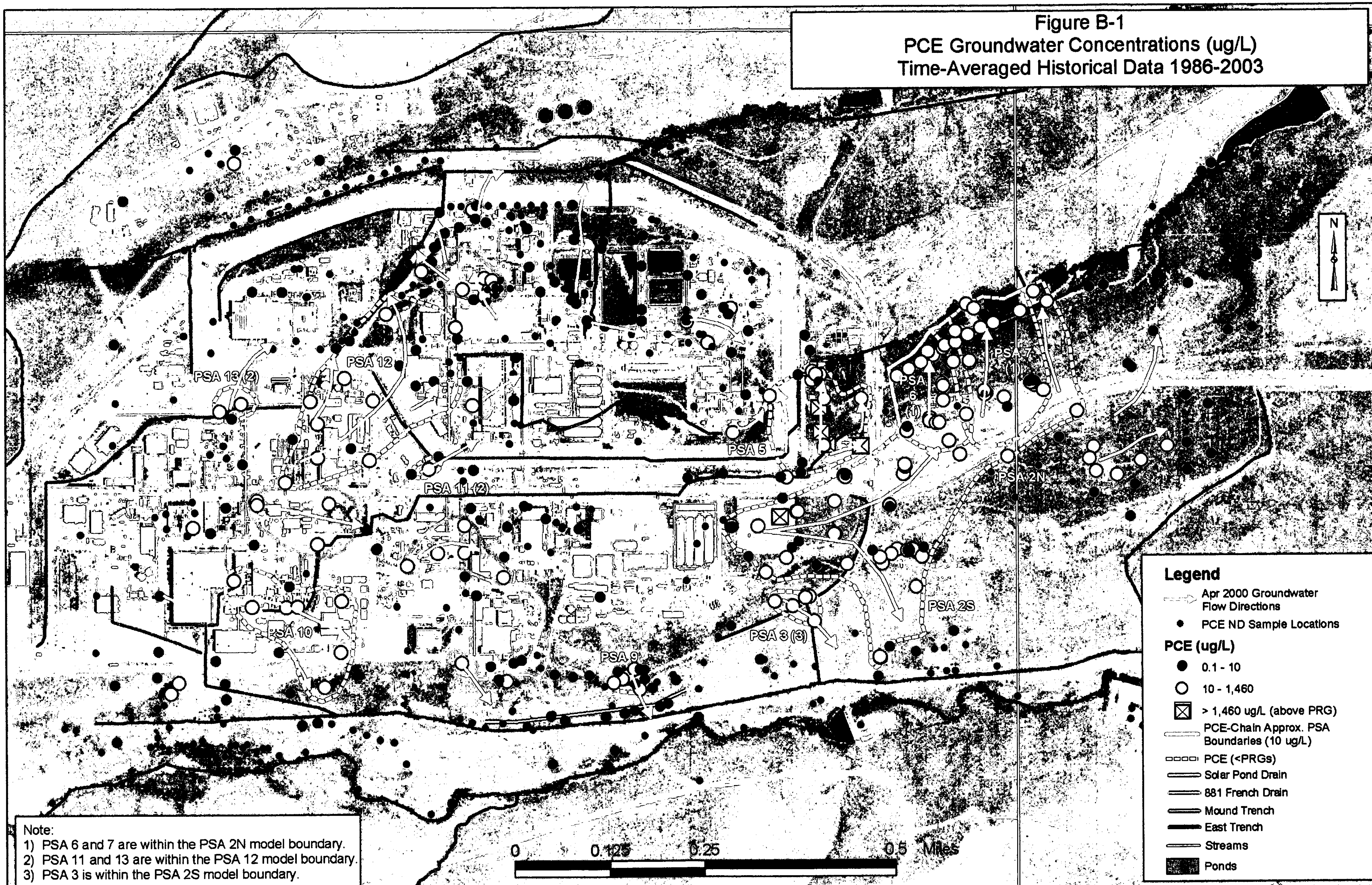
286



235

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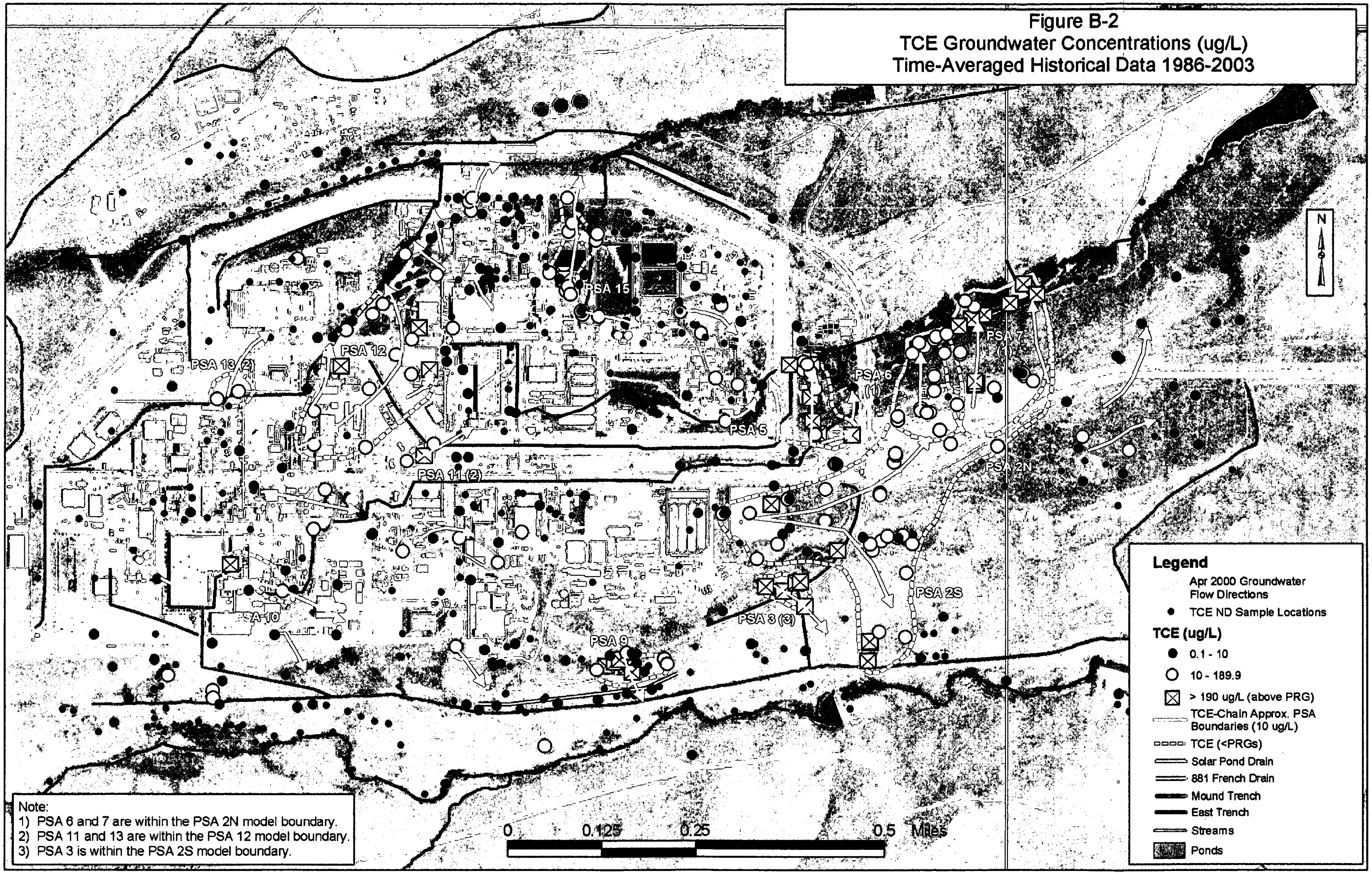

236

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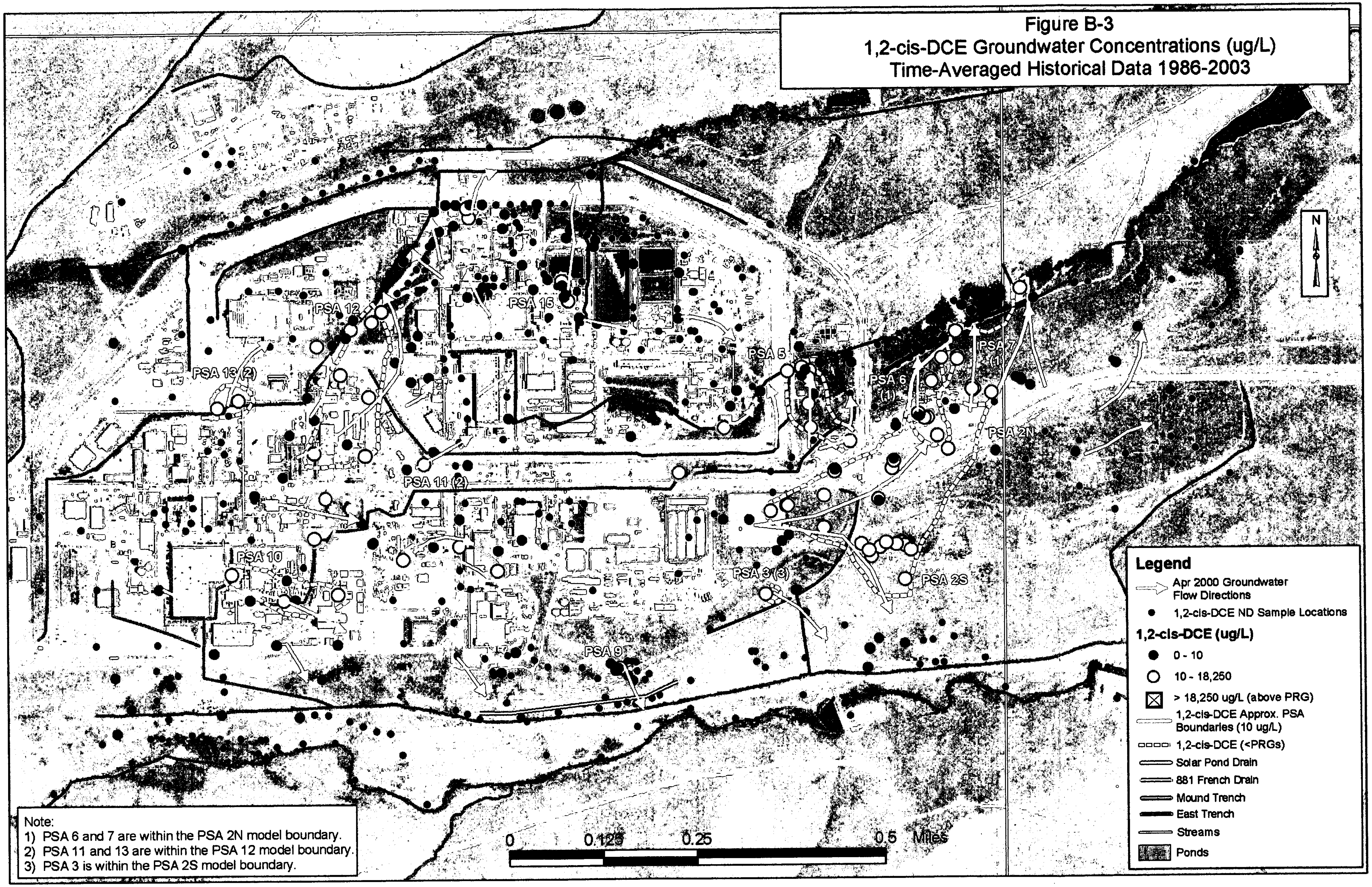


Figure B-3
1,2-cis-DCE Groundwater Concentrations (ug/L)
Time-Averaged Historical Data 1986-2003

237

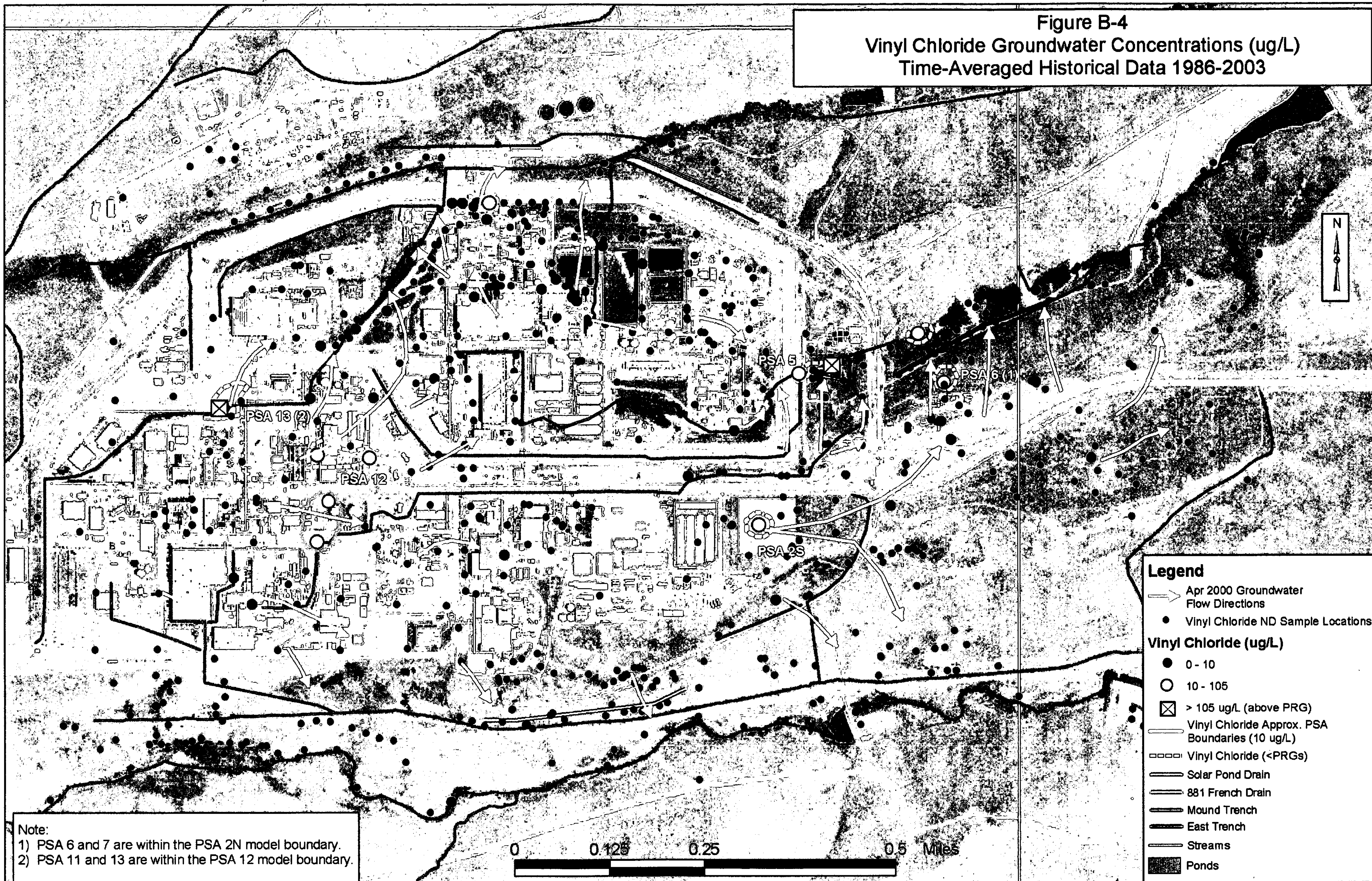
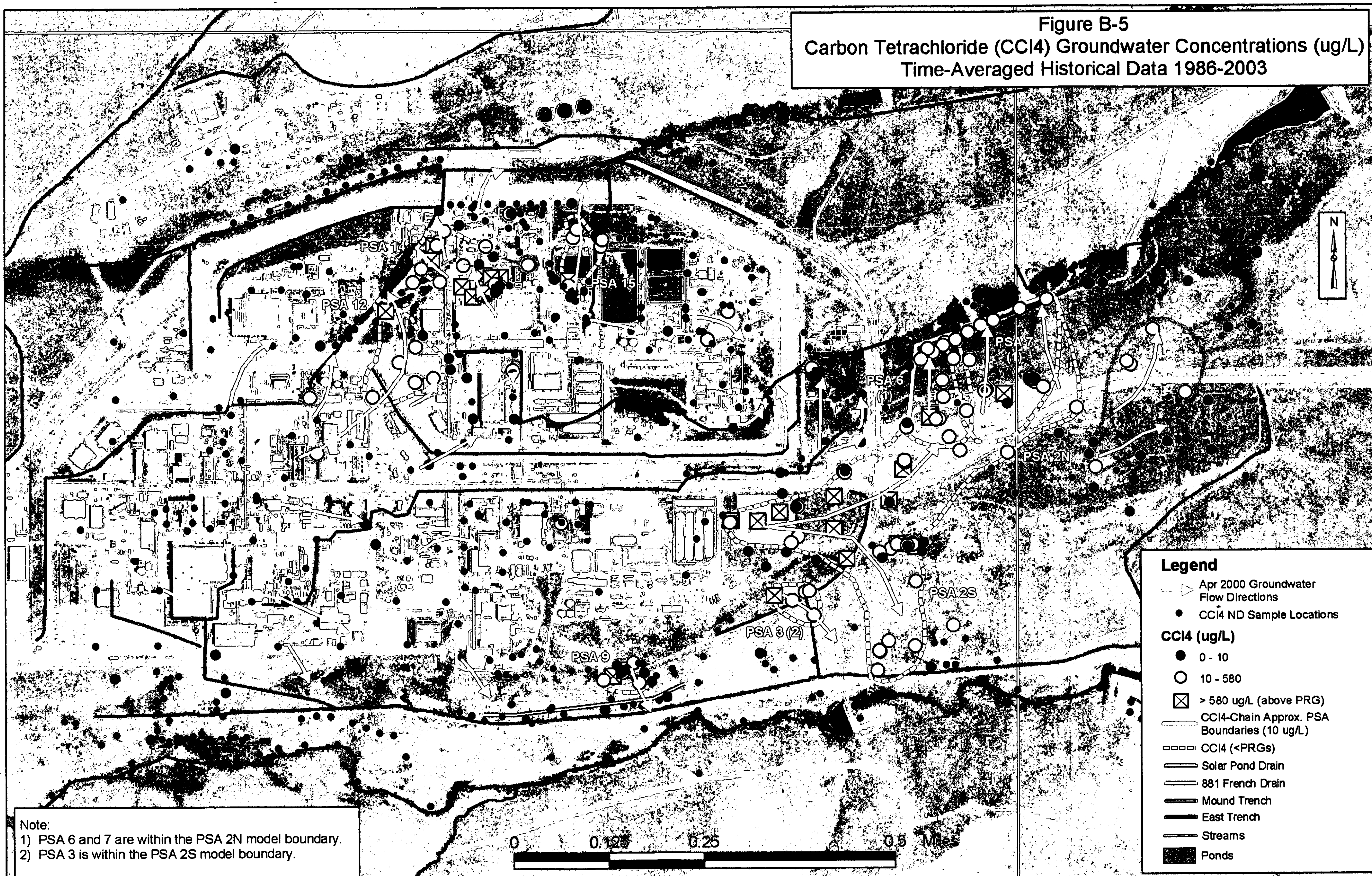


Figure B-4
Vinyl Chloride Groundwater Concentrations (ug/L)
Time-Averaged Historical Data 1986-2003

238



239

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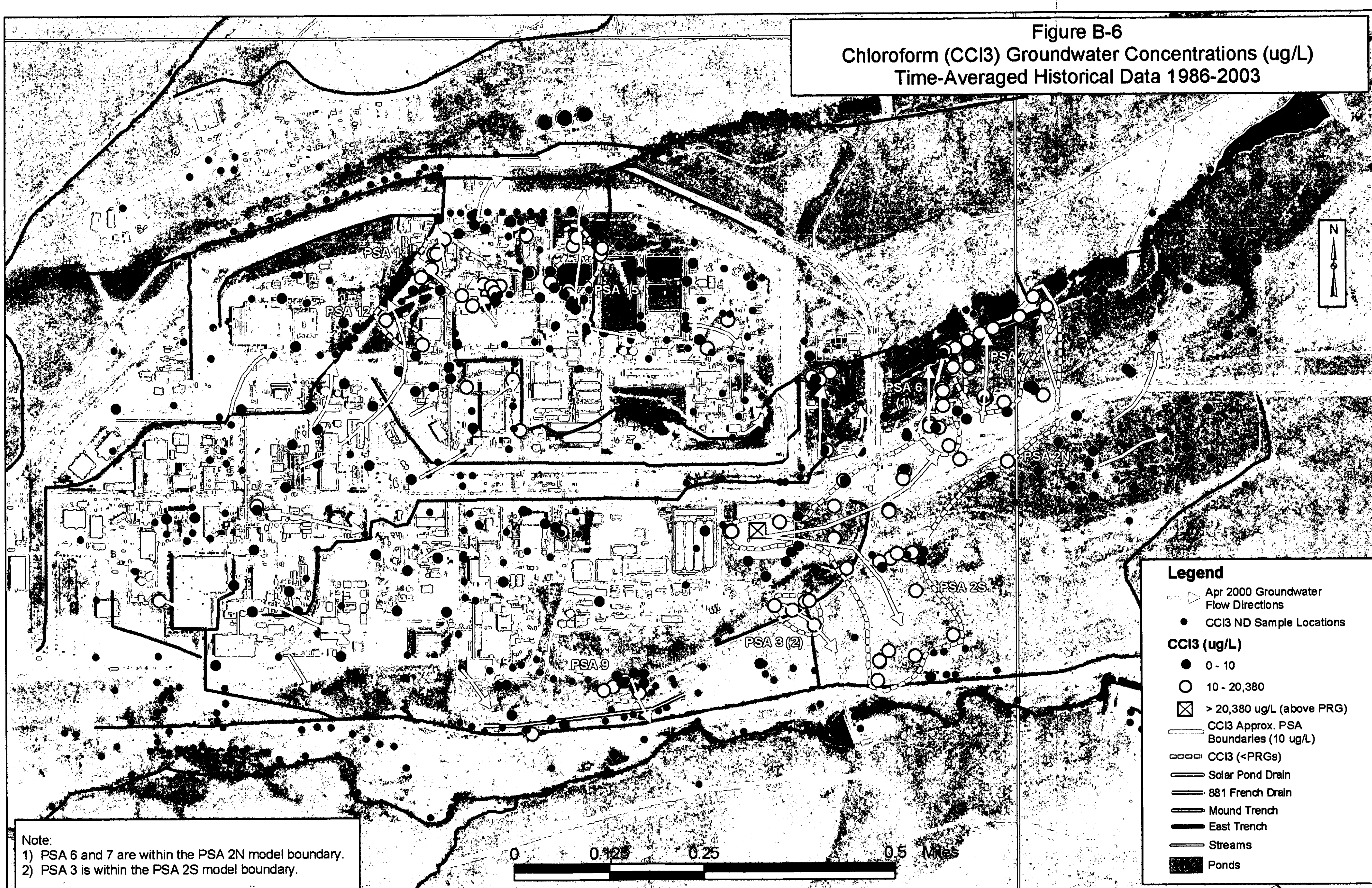

Figure B-6
Chloroform (CCl3) Groundwater Concentrations (ug/L)
Time-Averaged Historical Data 1986-2003
PSA 14
PSA 12
PSA 15
PSA 7 (1)
PSA 6 (1)
PSA 2N
PSA 2S
PSA 3 (2)
PSA 9
N
Legend
Apr 2000 Groundwater Flow Directions
CCl3 ND Sample Locations
CCl3 (ug/L)
0 - 10
10 - 20,380
> 20,380 ug/L (above PRG)
CCl3 Approx. PSA Boundaries (10 ug/L)
CCl3 (<PRGs)
Solar Pond Drain
881 French Drain
Mound Trench
East Trench
Streams
Ponds
0
0.125
0.25
0.5 Miles
Note:
1) PSA 6 and 7 are within the PSA 2N model boundary.
2) PSA 3 is within the PSA 2S model boundary.

240

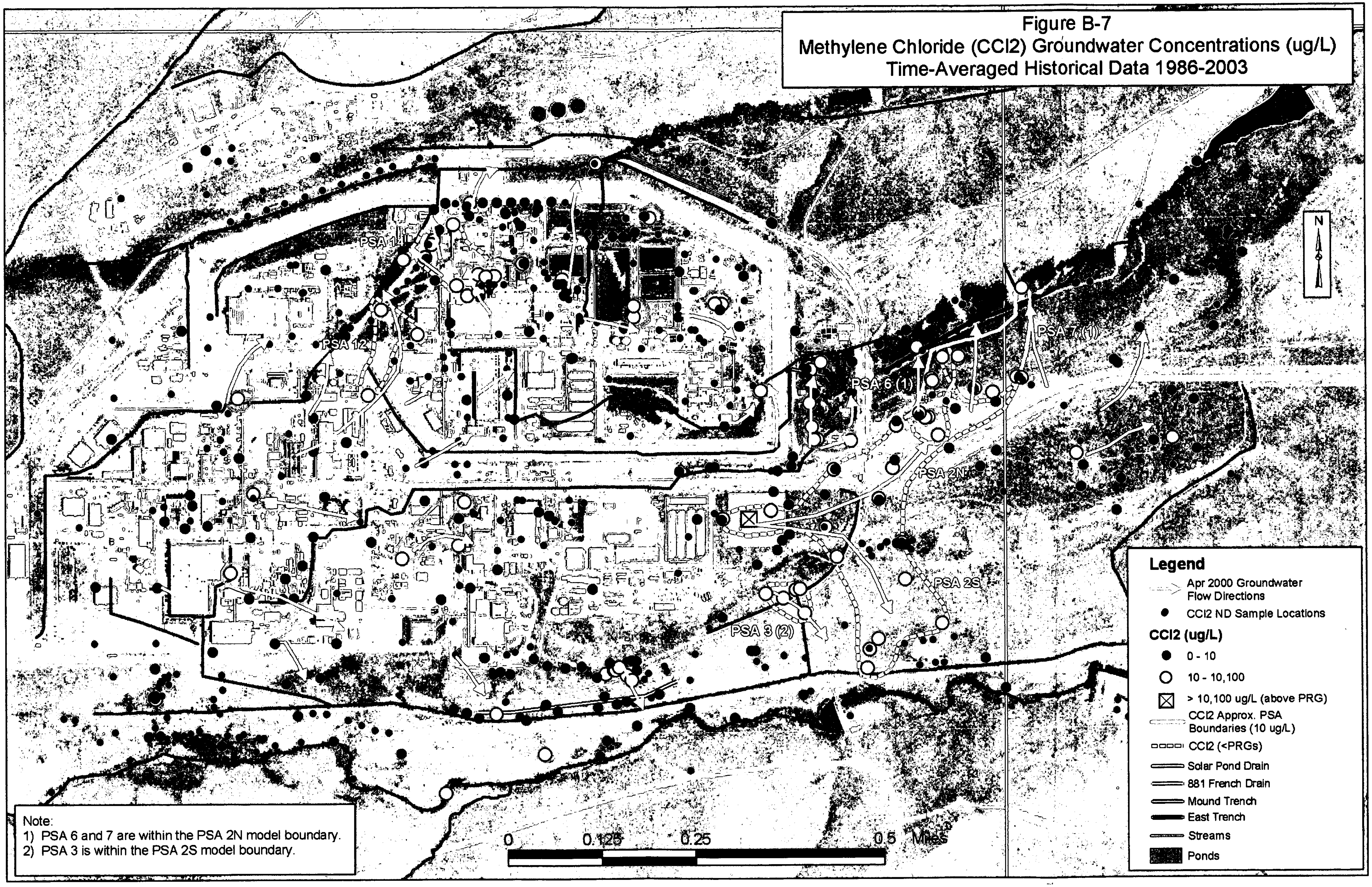

Figure B-7
Methylene Chloride (CCl2) Groundwater Concentrations (ug/L)
Time-Averaged Historical Data 1986-2003
N
PSA 1
PSA 12
PSA 6 (1)
PSA 7 (1)
PSA 2N
PSA 2S
PSA 3 (2)
Legend
Apr 2000 Groundwater Flow Directions
CCl2 ND Sample Locations
CCl2 (ug/L)
0 - 10
10 - 10,100
> 10,100 ug/L (above PRG)
CCl2 Approx. PSA Boundaries (10 ug/L)
CCl2 (<PRGs)
Solar Pond Drain
881 French Drain
Mound Trench
East Trench
Streams
Ponds
Note:
1) PSA 6 and 7 are within the PSA 2N model boundary.
2) PSA 3 is within the PSA 2S model boundary.
0
0.125
0.25
0.5
Miles

241